BUFFALO NATIONAL RIVER ECOSYSTEMS

PART I

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Water Resources Research Center

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FINAL REPORT

BUFFALO NATIONAL RIVER ECOSYSTEMS

1 APRIL 1974 - 31 MARCH 1975

Submitted by:

Project Director: R. E. Babcock

Project Coordinator: H. C. MacDonald

on Behalf of

Water Resources Research Center

University of Arkansas

Fayetteville, Arkansas 72701

for the Office of Natural Sciences,
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Service, Santa Fe, New Mexico
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FINAL REPORT OBJECTIVES AND PRIORITIES

Submitted to: National Park Service

Project: Ecosystem Studies, Buffalo National River

Contract No.: CX 700040182

1 April 74 to 31 March 75

Project Director: Dr. R. E. Babcock, Director
Arkansas Water Resources Research Center

In accordance with the priorities established during the meeting of the Buffalo National River research team and Mr. Roland Wauer, and outlined in Contract No. 700040182 dated May 17, 1974 the following data are provided as a final report. Specific priority objectives included:

Priority 1a. Water Quality Analysis and Monitoring (Seasonal)

Principal Investigator: Dr. D. G. Parker

Objective: Water quality analysis and monitoring as previously approved (1973), but sampling stations to be monitored a minimum of four times on a seasonal basis.

Priority 1b. Water Quality Analysis and Monitoring ("one-shot")

Principal Investigator: Dr. Joe F. Nix

Objective: "One-shot" water quality study sampling the main stem and several tributaries of the Buffalo National River. Water quality parameters to be measured as approved in the FY-1973 work statement reported on in Preliminary Reconnaissance Water Quality Survey of the Buffalo National River, WRRC Publication No. 19 dated October 1973.

Priority 1c. Geochemistry of Sediment and Water (Partial OWRT Funding)

Principal Investigator: Dr. Kenneth F. Steele

Objective: Geochemistry of sediments and heavy metal content of water as previously approved (1973), but sampling stations to be monitored a minimum of four times on a seasonal basis.

Priority 1d. Phycological Analysis

Principal Investigator: Dr. Richard L. Meyer

Objective: The primary objectives of the sampling program were to determine the distribution of the periphyton community. Pool vs. riffle association were to be collected along the length of the river at four intervals.

Priority 2a. Land Use Analysis with Remote Sensor Data

Principal Investigator: Dr. H. MacDonald

Objective: Level II land use mapping to be completed for the Buffalo National River watershed with emphasis given to proposed development sites.

Priority 2b. Provide an Insight to Visitor Use and "Resource Capacity"

Principal Investigators: Dr. R. E. Babcock, Dr. D. G. Parker

Objective: Provide an insight to visitor use and "Resource Capacity" which will take into account many of the Buffalo National River's physical characteristics.

Priority 3. Automatic Monitoring of Water Quality Data (OWRT Funding)

Principal Investigator: Dr. R. W. Raible

Objective: Evaluate digital ground-based, water quality, monitoring systems as an adjunct to field surveys.

Priority 4. Vegetation analyses are to be initiated during the next contract period.

Priority 5. Ichthyofauna Study (OWRT Funding)

Principal Investigators: Drs. D. A. Becker and R. V. Kilambi

Objective: A qualitative and quantitative study to be made of the distribution and abundance of fishes at selected areas with special emphasis on species diversity.

Priority 6. Ecological and hydrological parameters to be funded in the future.

Priority 7. Bottom Fauna Study (benthic macroinvertebrates)

Principal Investigator: Dr. Eugene H. Schmitz

Objective: To provide shallow-water, benthic, macroinvertebrate species inventory data for selected sites along the Buffalo National River. Study restricted to a single sampling trip because of insufficient funding.

SEASONAL WATER QUALITY ANALYSIS

Principal Investigator: D. G. Parker

The objective of this study was to sample the Buffalo River on a seasonal basis for a year, in order to determine whether any potential water quality problems existed.

Sample Stations

A description of the location of each permanent sampling station used during this study is as follows (site location, Figure 1).

1. Buffalo River at Boxley at highway 21 (River Mile 133)

1A. Buffalo River at Ponca at highway 74 (River Mile 128)

2. Buffalo River at Pruitt above confluence with Mill Creek (River Mile 102)

3. Little Buffalo River at Jasper at highway 7 (River Mile 7)

4. Buffalo River at Hasty at low water bridge (River Mile 96)

5. Buffalo River at Gilbert (River Mile 55)

6. Buffalo River at highway 14 (River Mile 33)

7. Buffalo River at Buffalo Point National Park above sewage treatment plant effluent (River Mile 31)

8. Buffalo River at Rush below confluence with Clabber Creek (River Mile 22)

Station 1A at Ponca was established because station 1 at Boxley had no flow at certain periods.

Methods

Temperature, color, turbidity and pH were measured in the field at the

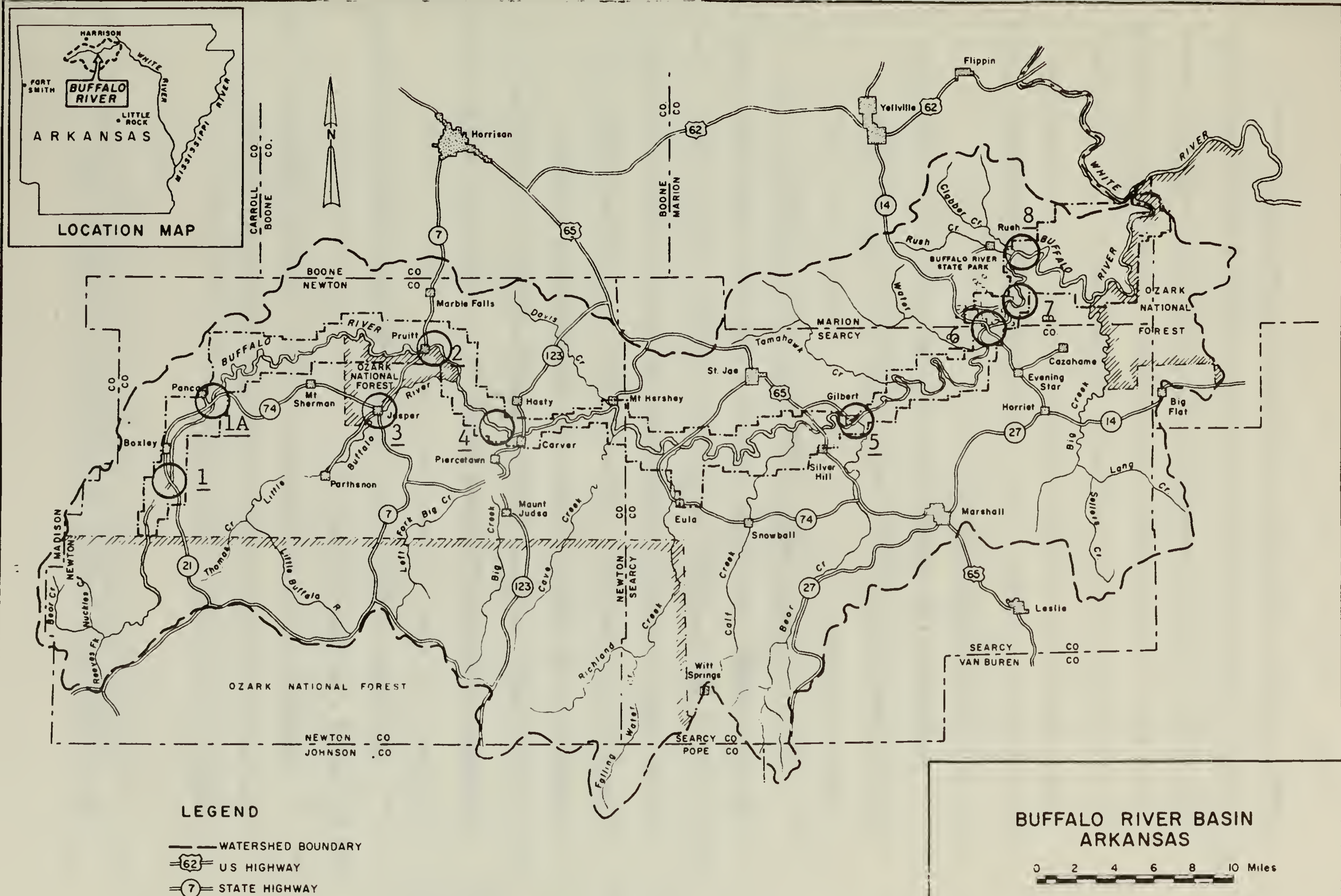

FIGURE 1. Sample Station Locations

Location of Rivers for measurements where?
Sample location same each time?

sample locations. Temperature was measured by a mercury thermometer. Color and turbidity were measured by use of a Hach portable engineer's laboratory. The pH was measured by a Corning model 6 portable pH meter with a Fisher Standard combination electrode. Alkalinity was determined by titration with acid as outlined in Standard Methods (1). Dissolved oxygen samples were collected and fixed in the field and titrated in the laboratory according to the azide modification of the Winkler method as outlined in Standard Methods (1).

Suspended solids samples were filtered in the field through glass fiber filters and the filters were transported to the laboratory for drying and weighing.

Three additional samples were collected and transported to the lab for analysis. One 500 ml sample was collected, filtered and stored on ice for iron, chloride, hardness and conductivity measurements. One 500 ml sample was collected and stored in a sterile plastic bottle for bacteriological analysis. One filtered 200 ml sample was stored in a glass bottle for ammonia, nitrate and orthophosphate analysis.

date of calibration?

Alkalinity, hardness and iron were determined in the laboratory by procedures outlined in Standard Methods (1). Conductivity was determined by using a YSI model 31 conductivity bridge.

Total organic carbon (TOC) and total inorganic carbon were measured by use of a Beckman TOC analyser.

Ammonia, nitrate and phosphate determinations were conducted by the Department of Botany and Bacteriology and these reports should be consulted for details of the analysis.

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[1] Standard Methods for the Examination of Water and Wastewater, 12th Edition, New York, American Public Health Association, 1965.

Bacteriological analyses were performed on unfiltered samples which were stored in autoclaved polypropylene bottles at approximately 4°C; membrane filter techniques as outlined in Standard Methods (1) were employed.

Discussion of Results

Water temperature (Table 1) changed significantly with time of year. The lowest temperature recorded was 5°C in December, and the highest was 29.5°C in August. This variation corresponds with the expected variation.

Dissolved oxygen concentration (Table 2) varied inversely with water temperature from a high of 13.2 mg/l in December to a low of 7.4 mg/l in August. This variation is the result of the effect of temperature on dissolved oxygen saturation. The percentage of saturation (Table 3) was consistently high with the lowest value recorded of 86 percent. This consistent high percentage of saturation indicates that presently there is no problem with oxygen demand in the river. This finding is consistent with the low total organic carbon measurements (Table 4) recorded during this study.

The physical parameters of color (Table 5), turbidity (Table 6) and suspended solids (Table 7) are all relatively low and do not show any patterns of seasonal change. These physical parameters have been observed to change significantly within a few hours after a rain, and these short term changes seem to be more significant than any seasonal changes.

were they corrected to 25°C?

Alkalinity (Table 8), hardness (Table 9) and conductivity (Table 10) increase in value in the downstream direction as previously reported.

Alkalinity appears to vary directly with the temperature, the lowest values occurring in December. The lowest values for hardness are also in December; however, the correlation with temperature is not very apparent during the remainder of the year.

The values of pH (Table 11), chlorides (Table 12) and iron (Table 13) do not appear to have any obvious seasonal trends.

Ammonia (Table 14), nitrate (Table 15) and phosphate (Table 16) were measured for only three days and therefore no seasonal judgements can be made; however, a more extensive evaluation of these parameters will be presented in the Botany-Bacteriology section of this report.

Total coliform, fecal coliform and fecal streptococcus organisms are test organisms used as indicators of fecal contamination in surface and groundwaters. The "Arkansas Water Quality Standards" for surface water suitable for primary contact recreation is - "Based on a minimum of not less than 5 samples taken over not more than a 30-day period, the fecal coliform content shall not exceed a log mean of 200/100 ml nor shall more than 10 percent of the total samples during any 30-day period exceed 400/100 ml" (2). The fecal coliform-fecal streptococcus ratio has been used by some investigators as a means of separating human from non-human contamination. Water containing ratios greater than 4 is assumed to be contaminated by human feces while ratios less than 1 generally indicate non-human animal contaminations. (3)

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[2] Arkansas Water Quality Standards, Regulation No. 2, as amended, Arkansas Dept. of Pollution Control and Ecology, September, 1973.

[3] Geldreich, E. E., and Kenner, B. A., "Concepts of Fecal Streptococci Water Pollution Control Federation Journal, R336, August, 1969.

The concentrations of total coliform (Table 16), fecal coliform (Table 17) and fecal streptococcus (Table 18) organisms vary significantly between different stations and from one sampling date to another. No clear seasonal variations are apparent from the recorded data; however, station variations are obvious. Station 3 at Jasper on the Little Buffalo shows consistently high concentrations of organisms. No station on the Buffalo River within the National Park has consistently high values for organisms. However, one sample at Rush and one at Hasty showed fecal coliform content in excess of the 400 coli/100 ml Arkansas requirement for water quality. The fecal coliform-fecal streptococcus ratios do not appear to have an obvious seasonal trend; however, both stations 3 and 4 show relatively high values indicating possible significant human input.

A knowledge of low flow conditions in a river is of prime importance in evaluating environmental conditions. Low flow data obtained from the U.S.G.S. indicate that the seven day-ten year expected low flow condition for the Buffalo River at Rush is 20 cfs and at Saint Joe is 14 cfs. (The seven day-ten year low flow is used by Arkansas in evaluating water quality.)

An estimate of the low flow values for other stations on the river can be made by assuming that low flow values are proportional to drainage area within the same river basin. The following is a table of estimated expected low flows determined by the above method.

Station	Estimated Expected 7 day-10 year low flow (cfs)
1A	2
2	3
3	2
4	8

Estimation of low flow in the river at any one point is difficult because during dry periods, the stream may flow under the stream bed in the gravel and rock for long stretches and no surface flow can be measured. In June and again in August, it was observed that there was no surface flow at station 1 at Boxley but there was substantial flow at station 1A at Ponca just 5 miles downstream.

Summary and Conclusions

An analysis of the results of water samples on the Buffalo National River to date indicates that, with one exception, the water quality in the river is good. The one exception is the possible fecal contamination present in the river as indicated by high fecal coliform concentrations. Human fecal contamination can be caused by many different factors including:

1. Direct body contact - recreational use of the river.
2. Improper or inadequate sewage treatment facilities (including improper septic tank and pit toilet installations).
3. The absence of sanitary facilities in remote areas.

The problem of high fecal bacteria is the concern of one phase of the research to be conducted during FY 76.

need flow measurements for each station at each date of measuring

TABLE 1 WATER TEMPERATURE (^{o}C)

	Date					
Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	22	---	---	---	6	12
1A	20	18.5	21.5	26	6.5	11.5
2	21	21	20.5	25	5	12
3	17	19	18.5	25	7	11
4	21	24	21	25.5	6	12
5	21	---	21.5	29	7	13
6	22	---	22	29.5	6.5	11
7	22	---	21.5	28.5	6	11
8	22	---	21	28	6	11

TABLE 2 DISSOLVED OXYGEN (mg/1)

1	9.0	---	---	---	12.3	10.9
1A	9.3	8.2	9.4	7.7	11.9	11.0
2	7.7	8.2	8.5	7.4	12.2	10.7
3	8.9	8.8	8.5	8.1	11.2	10.8
4	8.2	8.0	9.4	7.7	12.8	10.8
5	8.6	---	8.8	9.6	13.1	10.7
6	8.6	---	8.8	8.6	13.2	10.5
7	8.3	---	8.5	7.8	13.0	10.3
8	8.3	---	8.6	7.5	12.6	10.6

TABLE 3 DISSOLVED OXYGEN SATURATION (%)

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	1--+	---	---	---	98	100+
1A	100+	87	100+	94	96	100+
2	86	91	93	88	95	99
3	92	94	90	96	92	97
4	91	94	100+	93	100+	100
5	96	---	99	100+	100+	100+
6	98	---	100	100+	100+	96
7	94	---	96	100	100+	93
8	94	---	96	95	100+	95

TABLE 4 TOTAL ORGANIC CARBON/TOTAL INORGANIC CARBON

1	<1/6	---
1A	<1/8	<1/10
2	1/14	1/15
3	<1/15	<1/17
4	<1/17	1/19
5	2/21	---
6	1/23	---
7	3/23	---
8	2/27	---

TABLE 5 COLOR (Units)

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	---	---	---	---	20	15
1A	---	---	15	10	5	15
2	0	15	15	10	20	20
3	10	20	15	10	10	15
4	20	10	10	10	0	20
5	20	---	20	10	0	25
6	20	---	10	10	0	45
7	10	---	20	10	0	35
8	20	---	10	10	0	40

TABLE 6 TURBIDITY (JTU) (N-11) ?

1	---	---	---	---	5	4
1A	---	---	0	0	5	12
2	0	10	5	5	2	6
3	10	7	5	5	5	8
4	30 ?	0	0	5	0	7
5	0	---	5	5	0	7
6	10	---	5	5	0	12
7	10	---	5	5	0	14
8	10	---	5	5	0	18

TABLE 7 SUSPENDED SOLIDS (mg/l)

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	5.8	---	---	---	1.2	3.2
1A	3.5	2.5	2.6	1.9	1.3	3.3
2	3.4	3.1	3.2	2.1	4.1	4.4
3	4.1	2.4	2.9	2.2	2.0	4.4
4	3.7	5.1	4.9	1.7	2.1	6.9
5	---	---	7.6	2.1	1.6	5.8
6	4.9	---	5.9	0.5	2.5	8.2
7	5.0	---	5.7	16.9	0.3	9.5
8	7.4	---	4.4	0.4	1.8	14.2

TABLE 8 ALKALINITY (mg/l as $CaCO_3$)

1	29	---	---	---	29	27
1A	41	49	55	108	50	35
2	68	68	79	132	68	63
3	70	80	80	124	70	58
4	76	84	95	131	80	74
5	98	---	105	121	83	87
6	107	---	110	130	90	90
7	105	---	107	128	88	91
8	126	---	130	132	97	117

TABLE 9 HARDNESS (mg/1 as $CaCO_3$)

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	48	---	---	---	34	26
1A	59	51	55	120	52	40
2	72	71	81	124	76	70
3	80	83	83	130	78	64
4	95	87	96	134	88	80
5	112	---	110	124	88	94
6	150	---	113	136	94	96
7	122	---	112	132	100	96
8	140	---	132	134	102	120

TABLE 10 CONDUCTIVITY (µmhos/cm) @ 25°C

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	70	---	---	---	58	50
1A	92	78	80	189	83	72
2	126	109	120	189	121	120
3	138	117	120	201	131	115
4	150	121	164	205	141	143
5	192	---	153	193	151	160
6	197	---	146	197	158	167
7	197	---	145	189	157	167
8	233	---	178	202	166	207

TABLE 11 pH

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	7.3	---	---	---	7.0	7.4
1A	7.2	6.6	7.4	7.4	7.0	7.6
2	7.4	6.1	7.6	7.5	7.0	7.8
3	7.4	6.2	7.6	7.1	7.0	7.7
4	7.9	5.8	7.6	7.5	7.3	7.9
5	7.2	---	7.9	7.2	7.2	7.7
6	7.7	---	7.7	7.7	7.2	7.8
7	7.6	---	7.7	7.6	7.2	7.8
8	7.5	---	7.6	7.4	7.0	7.8

TABLE 12 CHLORIDES (mg/1)

1	1.4	---	---	---	3.0	2.5
1A	1.4	0.9	0.9	4.5	2.0	3.0
2	1.4	0.9	1.4	4.0	3.0	4.0
3	2.3	0.9	0.9	5.5	3.0	3.5
4	2.3	0.9	1.4	5.0	3.5	3.5
5	2.3	---	0.9	4.0	3.0	3.5
6	2.3	---	1.4	5.0	3.5	3.5
7	2.3	---	1.4	4.5	3.5	3.5
8	1.4	---	1.4	5.0	3.5	3.5

TABLE 13 IRON (mg/1)

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	0.4	---	---	---	0.05	
1A	0.3	0.011	0.2	0.05	0.05	
2	0.3	0.01	0.3	0.05	0.05	
3	0.2	0.004	0.1	0.05	0.03	
4	0.2	0.009	0.3	0.05	0.05	
5	0.2	----	0.2	0.05	0.03	
6	0.2	----	0.1	0.05	0.05	
7	0.2	----	0.1	0.05	0.05	
8	0.2	----	0	0.05	0.05	

TABLE 14 AMMONIA (mg/1-N)

1	0.003	----		----		
1A	0.003	0.003		0.025		
2	0.002	0.004		0.021		
3	0.003	0.004		0.087		
4	0.003	0.006		0.019		
5	0.003	----		0.017		
6	0.002	----		0.017		
7	0.003	----		0.017		
8	0.002	----		0.022		

TABLE 15 NITRATE (mg/1-N)

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	0.22	----		----		
1A	0.28	0.20		0.20		
2	0.24	0.20		0.18		
3	0.30	0.20		0.34		
4	0.27	0.27		0.24		
5	0.34	----		0.16		
6	0.36	----		0.20		
7	0.36	----		0.18		
8	0.32	----		0.16		

TABLE 16 PHOSPHATE, ORTHO (mg/1-P)

1	0.009	----		----		
1A	0.006	0.074		----		
2	0.004	0.065		0.006		
3	0.011	0.224		0.006		
4	0.004	0.08		0.013		
5	0.033	----		0.005		
6	0.013	----		0.004		
7	0.010	----		0.006		
8	0.010	----		0.036		

TABLE 17 FECAL COLIFORMS (Coli/100 ml)

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	43	---	---	---	8	0
1A	37	130	34	5	10	4
2	9	41	56	5	8	8
3	100	400	450	460	70	130
4	23	43	490	5	6	88
5	45	---	160	2	---	72
6	1	---	64	8	2	130
7	17	---	71	26	1	280
8	8	---	18	3	0	590

TABLE 18 FECAL STREPTOCOCCUS (Organisms/100 ml)

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	20	---	---	---	11	0
1A	44	44	58	37	6	4
2	25	13	72	23	9	10
3	100	120	120	42	16	20
4	8	11	130	9	7	28
5	51	---	70	21	8	36
6	35	---	51	4	1	55
7	43	---	58	14	4	96
8	39	---	43	12	2	270

TABLE 19 FECAL COLIFORM-FECAL STREPTOCOCCUS RATIO

Station	21-22 May	3-4 June	17-18 June	14-15 Aug	20 Dec	24 Mar
1	2.2	---	---	---	0.7	---
1A	0.8	0.3	0.6	0.1	1.7	1.0
2	0.4	3.2	0.8	0.2	0.9	0.8
3	1.0	3.4	3.7	18.1	4.4	6.5
4	2.9	3.9	3.8	0.6	0.9	3.1
5	0.9	---	2.0	0.1	---	2.0
6	0.1	---	1.3	2.0	2.0	2.4
7	0.4	---	1.2	1.9	0.3	2.9
8	0.2	---	0.4	0.3	---	2.2

INTENSIVE 'ONE SHOT' WATER QUALITY SURVEY OF BUFFALO RIVER, SPRING OF 1974

Principal Investigator: Joe F. Nix

Introduction

During the spring of 1973, an intensive water quality study of the Buffalo National River, Arkansas, was conducted. Field measurements and sample collections were made from canoes over a six day period beginning near river mile 138 and extending through river mile 33. Samples were taken periodically from the main channel of the river and from representative tributaries at their confluence with the Buffalo River. The results of this study were reported by Babcock et al.(4).

In an effort to verify observations made in the 1973 study, a similar study was conducted during the spring of 1974. The results of the 1974 investigation are given in this report. An attempt is made to compare these results with those taken during 1973.

Methods

On May 26, 1974, sampling and field measurements were begun near river mile 138. Sampling of the Buffalo River and tributaries from river mile 138 to 128 was accomplished by driving to sampling locations. The remainder of the field measurements and sampling was accomplished from canoes (beginning near Ponca, Arkansas on June 27, 1974). Samples were taken from the same locations as in the 1973 study. Since the 1973 survey did not extend downstream from river mile 33, it was necessary to establish new sites for this section of the river. The location of each sample

taken from the mainstream of the Buffalo River, along with the date of sampling, is given in Table 1. The same information for tributaries of the Buffalo is given in Table 2.

The analytical methods used in this study were described in the 1973 report (4). Alkalinity was measured at the end of each day during the 1974 study. Although this measurement was made on samples returned to the laboratory during the 1973 study, comparison of measurements made in the field with sam- those on samples stored for one week indicates that one week storage did not cause a significant change in alkalinity.

Results and Discussion

The results of analysis of field measurements and samples taken from the mainstream of the Buffalo River are given in Table 22 and those for tributaries in Table 23. The data from the mainstream of the river are also shown in Figures 2 through 16 . In order to make a comparison, the 1973 data are shown as circles connected by a solid line while the 1974 data are shown as triangles connected by a dotted line.

It should be noted that immediately prior to and during the 1973 survey, rain showers were experienced throughout the entire Buffalo River watershed. Significant rain had not occurred for several days prior to the 1974 study. Although no measurements were made, it was estimated that the flow of the Buffalo River was slightly lower during the 1974 study.

Maximum, minimum, and mean values for water quality parameters in the main stem of the Buffalo River are summarized in Table 24. Comparison with the corresponding table in the 1973 report indicates that specific conductance, alkalinity, and calcium were significantly higher during the 1974 study and that

sodium, potassium, and chloride were slightly lower. When comparing these values, one should remember that an additional 33 miles of river was surveyed in 1974.

As shown in Figure 2, the slight increase in temperature in a downstream direction which was observed in 1973 was also observed in 1974. Diurnal cooling and warming were apparent with minimum temperatures being observed during the early morning hours and maximum values in mid afternoon.

With the exception of the expected diurnal cycling of dissolved oxygen, Figure 3 indicates that dissolved oxygen concentrations were near and above saturation throughout the full length of the river.

Specific conductance values (Figure 4) show a marked increase in a downstream direction. Calcium (Figure 6), magnesium (Figure 7), and alkalinity (Figure 5) show similar trends. These data indicate that, in general, the river continues to dissolve limestone and/or dolomitic rock as it moves through the dissected Ozark Plateau.

Although the general trend for calcium, magnesium, and alkalinity is to increase in a downstream direction, the rate of increase obviously becomes less in the downstream section of the river as indicated by a flattening of these curves below river mile 40.

Several of the fine structural features of the graphs showing the concentration of calcium and magnesium as a function of river mile were observed in 1973 and again in 1974. A notable example is the sharp decrease of calcium and, to a much greater extent, magnesium near river mile 80. An inspection of the Geological Map of Arkansas (5) indicates that near river mile 80, the Buffalo River leaves a section of predominantly St. Peter Sandstone and Everton Limestone and enters a region dominated by a variety of

TABLE 20

Location of points which were sampled on the main stream of the Buffalo River

SAMPLE NUMBER	DATE SAMPLED	LOCATION
1	5/26/74	At Hedges home above Boxley
2	5/26/74	Buffalo River above Boxley
4	5/27/74	Ponca Bridge
5	5/27/74	Wrecking Rock
8	5/27/74	Confluence at Sneed Creek
9	5/27/74	Above confluence with Indian Creek
10	5/27/74	Camp Orr
11	5/27/74	2.5 miles below Camp Orr
12	5/27/74	2.5 miles above Pruitt
15	5/27/74	0.5 miles above confluence with Sawmill Hollow
16	5/27/74	Bill Houghton Canoe Place
17a	5/28/74	Below Pruitt (below Hwy. 7 Bridge)
19	5/28/74	1/4 mile above confluence with Boomer Hollow
21	5/28/74	Wells Creek
22	5/28/74	Confluence with Wells Creek
23	5/28/74	1/4 mile below Hasty Bridge
25	5/28/74	Highway 123 Bridge
26	5/28/74	2.5 mile below Big Creek
28	5/28/74	Highway 27
30	5/28/75	Mt. Hersey
32	5/28/75	Confluence with Cane Creek
33	5/28/74	The 'Narrs'

Table 20 (con't)

SAMPLE NUMBER	DATE SAMPLED	LOCATION
35	5/28/74	Confluence with Richland Creek
36a	5/29/74	Confluence with Richland Creek
37	5/29/74	1/2 mile above White Ford
38	5/29/74	Near Peter Cave
40	5/29/74	Red Bluff
41	5/29/74	Arnold Bend
43	5/29/74	Immediately downstream from confluence with Calf Creek
44	5/29/74	Highway 65
44a	5/29/74	Below Highway 65
46	5/29/74	Gilbert
46a	5/30/74	Gilbert
47	5/30/74	1/4 mile above old railroad crossing
48	5/30/74	Below confluence with Ezell Hollow
50	5/30/74	Below Tomahawk Creek
51	5/30/74	1.5 miles above Maumee
52	5/30/74	1/2 mile above Maumee
54	5/30/74	
56	5/30/74	1 mile below Spring Creek
58	5/30/74	Confluence with Water Creek
59	5/30/74	Highway 14 Bridge
60	5/31/74	Lower end of State Park
62	5/31/74	Confluence with Panther Creek
63	5/31/74	1/4 mile below Jones Hollow
64	5/31/74	1/4 mile above gauging station
67	5/31/74	Confluence with Clabber Creek
68	6/1/74	1/2 mile below Clabber Creek
69	6/1/74	1/2 mile above Lonely Hollow
71	6/1/74	Fish Trap Hollow

SAMPLE NUMBER	DATE SAMPLED	LOCATION
73	6/1/74	Big Creek
76	6/1/74	Leatherwood Creek
77	6/1/74	1/2 mile below Cow Creek
79	6/1/74	Stewart Creek
80	6/1/74	1/4 mile from confluence with White River
81	6/1/74	White River above confluence with Buffalo River

TABLE 21

Location of points which were sampled on tributaries of the Buffalo River. All tributaries were sampled at their confluence with the Buffalo River.

SAMPLE NUMBER	DATE SAMPLED	LOCATION
3	5/26/74	Beech Creek
6	5/27/74	Steel Creek
7	5/27/74	Sneed Creek
13	5/27/74	East tributary due east of Adair Cemetary
14	5/27/74	North tributary south of Conard Fissure
17	5/28/74	Mill Creek at Pruitt
18	5/28/74	Upstream from Boomer Hollow
20	5/28/74	Little Buffalo River
21	5/28/74	Wells Creek
24	5/28/74	Big Creek
27	5/28/74	North tributary 1 1/2 mile upstream from Mt. Hersey
29	5/28/74	Davis Creek at Mt. Hersey
31	5/28/74	Cane Creek
34	5/28/74	Richland Creek
36	5/29/74	Ben Branch
39	5/29/74	Rocky Hollow
42	5/29/74	Calf Creek
45	5/29/74	Dry Creek at Gilbert
47a	5/30/74	Bear Creek
49	5/30/74	Tomahawk Creek

SAMPLE NUMBER	DATE SAMPLED	LOCATION
52	5/30/74	Spring on west bank of river 1 mile upstream from Maumee
53	5/30/74	Maumee Hollow
55	5/30/74	Spring Creek
57	5/30/74	Water Creek
61	5/31/74	Panther Creek
65	5/31/74	Rush Creek
66	5/31/74	Clabber Creek
70	6/1/74	Fish Trap Hollow
72	6/1/74	Big Creek
74	6/1/74	Bear Hollow
75	6/1/74	Leatherwood Creek
78	6/1/74	Stewart Creek

TABLE 22

RESULTS OF ANALYSIS OF SAMPLES FROM BUFFALO RIVER

Sample Number	Temp. ^{0}C	D.O. ppm	pH	Sp. Cond. Mhos	Na ppm	K ppm	Ca ppm	Mg ppm	Fe ppm	Mn ppm	Zn ppm	Cl ppm	SO_4 ppm	PO_4 ppm	Alk ppm	NO_3 ppm
1	17.6	9.4	7.2	68	0.9	0.9	10	1.1	0.40	<0.05	0.01	1.1	5.0	0.01	26	0.1
2	17.0	10.0	7.3	79	0.9	0.6	10	1.0	0.20	<0.05	0.00	1.3	8.2	0.01	31	0.1
4	16.1	10.0	7.3	100	1.0	1.9	16	1.2	0.20	<0.05	0.00	1.2	9.6	0.07	42	0.1
5	16.6	10.1	7.3	105	1.0	0.9	20	1.4	0.10	<0.05	0.00	1.1	8.0	0.02	45	0.0
8	17.8	10.0	7.5	122	1.1	0.6	18	1.6	<0.05	<0.05	0.00	1.1	9.2	0.00	51	0.0
9	19.4	10.4	7.5	130	1.1	0.9	21	1.4	<0.05	<0.05	0.00	1.1	8.6	0.02	55	0.2
10	19.4	10.6	7.5	138	1.1	0.8	22	1.5	<0.05	<0.05	0.00	1.0	7.0	0.00	57	0.0
11	20.3	10.6	7.6	151	1.1	0.8	23	1.5	<0.05	<0.05	0.00	1.0	8.0	0.00	63	0.0
12	20.9	10.4	7.7	172	1.2	1.0	29	2.0	<0.05	<0.05	0.01	1.3	7.0	0.00	74	0.1
15	21.3	9.1	7.7	182	1.1	0.8	27	1.8	<0.05	<0.05	0.01	1.4	8.8	0.00	71	0.0
16	22.6	8.8	7.6	182	1.2	0.8	29	1.8	<0.05	<0.05	0.02	1.3	9.0	0.00	75	0.0
17A	19.2	9.0	7.4	176	1.2	0.9	28	1.8	<0.05	<0.05	0.02	1.3	9.2	0.00	76	0.0
19	19.6	8.7	7.4	206	1.3	0.8	34	2.0	<0.05	<0.05	0.00	1.4	11.3	0.00	87	0.1
22	19.5	9.6	7.5	194	1.3	0.9	36	1.9	<0.05	<0.05	0.03	1.3	7.4	0.02	85	0.2
23	19.2	10.2	7.6	204	1.2	0.9	30	1.9	<0.05	<0.05	0.00	1.5	6.5	0.02	86	0.2
25	20.8	10.4	7.6	218	1.4	1.0	36	2.0	<0.05	<0.05	0.01	1.4	6.7	0.03	89	0.1
26	22.1	10.4	7.7	249	1.2	0.7	36	2.0	<0.05	<0.05	0.01	1.4	3.9	0.02	93	0.0
28	22.2	10.0	7.7	258	1.3	0.9	37	2.1	<0.05	<0.05	0.01	1.4	8.6	0.01	94	0.0
30	23.1	10.4	7.8	248	1.3	0.8	38	2.2	<0.05	<0.05	0.00	1.5	8.3	0.03	96	0.1

Table 22(con't)

Sample Number	Temp. ^0C	D.O. ppm	pH	Sp. Cond. Mhos	Na ppm	K ppm	Ca ppm	Mg ppm	Fe ppm	Mn ppm	Zn ppm	Cl ppm	SO_4 ppm	PO_4 ppm	Alk ppm	NO_3 ppm
32	23.6	10.0	7.7	285	1.2	0.8	41	2.6	<0.05	<0.05	0.00	1.7	6.9	0.03	104	0.1
33	22.8	10.4	7.7	285	1.3	0.8	42	2.5	<0.05	<0.05	0.00	1.6	7.9	0.04	104	0.1
35	21.6	10.2	7.8	301	1.3	0.9	37	2.5	<0.05	<0.05	0.00	1.7	7.7	0.06	105	0.3
36A	21.2	8.4	7.6	241	1.3	0.9	43	2.6	<0.05	<0.05	0.00	1.7	3.2	0.04	106	0.1
37	21.6	9.0	7.6	228	1.2	0.7	36	2.2	<0.05	<0.05	0.00	1.4	8.9	0.03	90	0.0
38	22.0	8.4	7.6	227	1.2	0.7	36	2.1	<0.05	<0.05	0.02	1.4	5.3	0.03	94	0.2
40	22.0	9.2	7.6	223	1.2	0.7	34	2.1	<0.05	<0.05	0.00	1.4	8.8	0.03	92	0.1
41	21.7	9.2	7.7	210	1.2	0.8	35	2.0	<0.05	<0.05	0.00	1.5	7.6	0.03	92	0.2
43	22.0	9.7	7.8	228	1.3	0.9	38	2.2	<0.05	<0.05	0.00	1.4	5.3	0.03	98	0.1
44	22.5	9.4	7.8	221	1.2	0.8	38	2.1	<0.05	<0.05	0.00	1.5	10.9	0.03	99	0.2
44A	23.0	9.6	7.8	236	1.3	0.9	40	2.1	<0.05	<0.05	0.01	1.7	7.4	0.02	98	0.5
46	22.0	10.1	7.7	228	1.2	0.8	40	2.1	<0.05	<0.05	0.00	1.5	5.3	0.06	99	0.2
46A	21.8	8.0	7.6	228	1.4	1.0	40	2.0	<0.05	<0.05	0.01	1.6	9.7	0.07	104	0.2
47	21.4	8.9	7.6	250	1.4	0.9	40	2.0	<0.05	<0.05	0.01	1.5	3.2	0.09	100	0.2
48	21.9	9.3	7.7	260	1.3	0.8	40	2.0	<0.05	<0.05	0.00	1.5	3.1	0.07	104	0.1
50	22.5	9.5	7.7	279	14.	0.8	44	2.3	<0.05	<0.05	0.01	1.6	6.5	0.07	105	0.1
51	23.3	9.7	7.7	279	1.3	0.8	40	2.2	<0.05	<0.05	0.02	1.7	3.2	0.06	107	0.2
52	23.2	9.7	7.8	290	1.3	0.8	42	2.5	<0.05	<0.05	0.00	1.8	7.9	0.01	107	0.0
54	25.5	10.1	7.8	285	1.2	0.8	43	2.3	<0.05	<0.05	0.02	1.8	6.6	0.07	108	0.0
56	25.8	10.7	7.8	282	1.3	0.8	43	2.6	<0.05	<0.05	0.02	1.7	9.0	0.01	112	0.1

Sample Number	Temp. °C	D.O. ppm	pH	Sp. Cond. Mhos	Na ppm	K ppm	Ca ppm	Mg ppm	Fe ppm	Mn ppm	Zn ppm	Cl ppm	SO_4 ppm	PO_4 ppm	Alk ppm	NO_3 ppm
58	25.8	11.0	7.8	255	1.2	0.8	42	2.5	0.05	0.05	0.00	1.7	9.7	0.07	107	0.0
59	25.8	10.8	7.8	265	1.2	0.8	42	2.4	0.05	0.05	0.02	1.6	7.4	0.06	108	0.0
60	22.9	8.5	7.7	256	1.3	0.8	44	2.4	0.05	0.05	0.02	1.8	4.3	0.07	112	0.0
62	22.5	8.6	7.7	259	1.3	0.8	44	2.4	0.05	0.05	0.02	1.6	4.7	0.07	112	0.2
63	23.6	8.4	7.7	261	1.3	0.8	43	2.4	0.05	0.05	0.00	1.7	8.1	0.06	111	0.0
64	23.5	8.6	7.7	263	1.3	0.9	43	2.4	0.05	0.05	0.00	1.6	4.2	0.06	112	0.0
67	23.7	8.2	7.7	269	1.3	0.9	45	2.6	0.05	0.05	0.00	1.8	6.2	0.07	111	0.1
68	21.1	7.9	7.6	258	1.4	1.0	45	2.2	0.05	0.05	0.00	1.6	15.6	0.07	107	0.2
69	21.5	8.3	7.6	265	1.3	0.9	46	2.5	0.05	0.05	0.00	1.7	8.6	0.07	109	0.1
71	21.4	8.4	7.7	272	1.2	0.8	46	2.7	0.05	0.05	0.01	1.7	3.6	0.07	110	0.1
73	25.1	8.2	7.7	279	1.2	0.9	46	2.6	0.05	0.05	0.01	1.6	9.9	0.07	112	0.0
76	22.9	8.8	7.7	278	1.4	1.0	47	3.0	0.05	0.05	0.00	1.6	10.0	0.09	117	0.4
77	24.1	9.5	7.7	298	1.3	0.9	50	3.1	0.05	0.05	0.01	1.6	6.2	0.09	117	0.4
79	24.6	9.0	7.7	304	1.3	0.9	48	2.1	0.05	0.05	0.02	1.8	8.6	0.09	118	0.0
80	24.9	9.6	7.7	317	1.2	0.9	47	2.2	0.05	0.05	0.01	1.6	9.7	0.09	118	0.0

TABLE 23

RESULTS OF ANALYSIS OF SAMPLES FROM BUFFALO RIVER TRIBUTARIES (1974)

Sample Number	Temp. ^{0}C	D.O. ppm	pH	Sp. Cond. Mhos	Na ppm	K ppm	Ca ppm	Mg ppm	Fe ppm	Mn ppm	Zn ppm	Cl ppm	SO_4 ppm	PO_4 ppm	Alk ppm	NO_3 ppm
3	17.5	9.7	7.4	102	1.7	1.1	16	1.2	0.05	0.05	0.02	2.5	10.9	0.01	45	0.2
6	16.7	9.3	7.2	203	-	-	20	-	0.05	0.05	-	-	-	--	54	0.8
7	18.5	10.8	7.8	261	1.6	1.0	48	2.4	0.05	0.05	-	2.8	20	0.01	128	0.2
13	20.1	10.0	7.4	431	1.3	0.6	63	1.0	0.05	0.05	0.02	2.6	17.6	0.01	259	0.2
14	24.5	8.3	7.6	390	1.9	0.9	59	1.5	0.05	0.05	0.02	4.2	15.1	0.02	179	0.1
17	19.2	9.1	7.4	176	2.6	0.1	76	2.2	0.05	0.05	0.02	4.3	13.7	0.01	179	0.1
18	17.0	5.2	7.6	332	-	-	44	-	0.05	0.05	-	-	-	-	181	-
20	19.1	9.3	7.5	182	1.2	0.8	31	-	0.05	0.05	0.01	1.2	5.0	0.00	80	0.0
21	17.5	9.4	7.9	319	3.2	0.4	64	2.2	0.05	0.05	0.04	9.8	-	-	172	0.6
24	20.6	10.1	7.7	247	2.0	0.9	43	1.6	0.05	0.05	0.02	2.5	12.5	0.01	104	0.4
27	16.4	10.6	7.4	325	1.8	1.6	61	1.8	0.05	0.05	0.03	2.8	16.1	0.01	166	0.6
29	20.4	10.2	7.6	387	1.3	0.8	58	4.7	0.05	0.05	0.02	2.2	10.6	0.01	196	0.3
31	21.3	9.7	7.6	357	1.6	1.1	57	3.1	0.05	0.05	0.02	2.6	19.9	0.01	155	0.2
34	22.2	9.7	7.6	178	1.8	0.9	16	1.0	0.05	0.05	0.04	2.0	10.5	0.01	42	0.3
36	21.2	8.4	7.6	241	1.6	1.0	35	1.8	0.05	0.05	0.02	2.6	14.5	0.01	97	0.2
39	18.2	7.9	7.3	382	1.8	1.0	82	0.7	0.05	0.05	0.01	4.1	9.8	0.01	207	0.6
42	21.1	9.8	7.5	312	2.0	1.1	56	1.6	0.05	0.05	0.03	3.4	11.0	0.01	143	0.2
45	20.1	9.4	7.6	380	2.2	1.2	73	0.9	0.05	0.05	0.02	3.4	12.6	0.01	90	0.4

Table 23 (con't)

Sample Number	Temp. ^{0}C	D.O. ppm	pH	Sp. Cond. Mhos	Na ppm	K ppm	Ca ppm	Mg ppm	Fe ppm	Mn ppm	Zn ppm	Cl ppm	SO_4 ppm	PO_4 ppm	Alk ppm	NO_3 ppm
47A	20.3	8.7	7.5	280	2.0	1.0	52	1.5	0.05	0.05	0.02	2.8	17.9	0.04	92	0.4
49	19.5	10.0	7.8	370	1.8	0.9	69	5.9	0.05	0.05	0.02	5.8	18.7	0.01	196	0.4
52	16.1	9.0	7.4	383	2.2	1.2	67	12.8	0.05	0.05	0.02	6.8	23	0.01	106	0.6
53	15.6	10.3	7.3	305	1.6	0.9	67	4.0	0.05	0.05	0.02	2.8	17.9	0.04	178	0.5
55	18.8	10.7	7.7	291	1.6	-	60	3.8	0.05	0.05	0.06	3.4	3.2	0.01	155	1.0
57	25.5	10.8	7.7	350	1.8	0.9	58	4.5	0.05	0.05	0.02	2.9	3.3	0.02	164	0.2
61	15.0	9.6	7.3	256	2.1	1.0	51	3.0	0.05	0.05	0.01	4.3	3.3	0.03	137	0.2
65	17.2	10.3	7.6	332	1.6	1.0	61	5.5	0.05	0.05	0.17	2.1	3.2	0.02	182	0.2
66	21.3	9.4	7.8	480	1.2	-	54	10.7	0.05	0.05	0.04	2.0	22	0.03	243	0.2
70	16.2	7.1	7.3	378	0.8	0.6	46	10.4	0.05	0.05	0.01	1.5	17.6	0.02	199	0.2
72	19.0	10.0	7.7	327	1.4	0.9	58	3.2	0.05	0.05	0.00	1.8	4.3	0.01	147	0.1
74	18.3	9.4	7.5	407	1.0	0.5	46	10.6	0.05	0.05	0.01	2.0	22	0.06	228	0.2
75	19.8	10.2	7.8	384	1.0	0.7	55	10.1	0.05	0.05	0.01	2.0	19.2	0.03	196	0.1
78	22.0	10.2	7.7	436	1.1	0.9	52	10.1	0.05	0.05	0.00	2.1	23	0.03	227	0.1

TABLE 24

Range and mean values of analysis of samples taken from the mainstream of the Buffalo River.

PARAMETER	MINIMUM VALUE	MAXIMUM VALUE	MEAN VALUE
temperature (^{0}C)	16.1	25.8	21.4
dissolved oxygen (ppm)	8.0	11.0	9.5
pH	7.2	7.8	7.6
specific conductance (mhos)	68	317	229
sodium (ppm)	0.9	1.4	1.3
potassium (ppm)	0.6	1.9	0.9
calcium (ppm)	10	50	36
magnesium (ppm)	1.0	3.1	2.1
iron (ppm)	0.05	0.40	0.06
manganese (ppm)	.05	.05	0.05
zinc (ppm)	0.00	0.03	0.01
chloride (ppm)	1.0	1.8	1.5
fluoride (ppm)			
sulfate (ppm)	3.1	15.6	7.4
phosphate, ortho (ppm)	0.00	0.09	0.04
alkalinity (ppm)	26	118	93
nitrate (ppm)	0.0	0.5	0.1

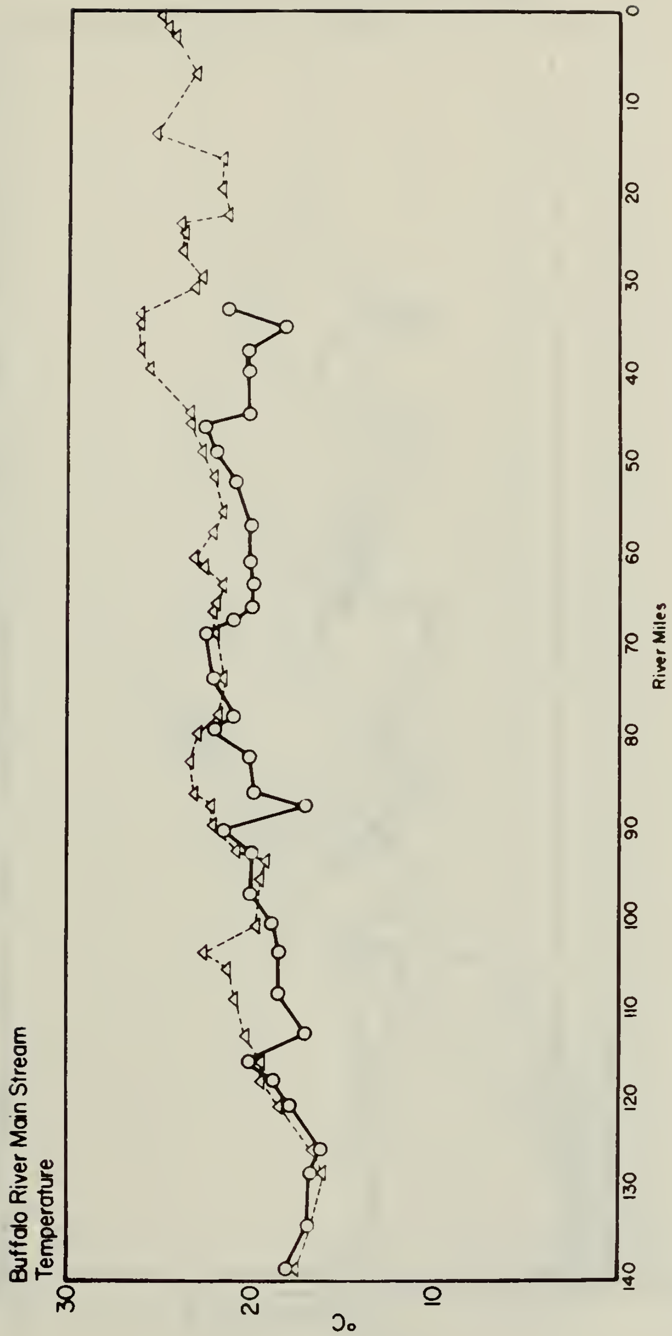

Buffalo River Main Stream
Temperature
30
20
10
°C
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
River Miles

FIGURE 2

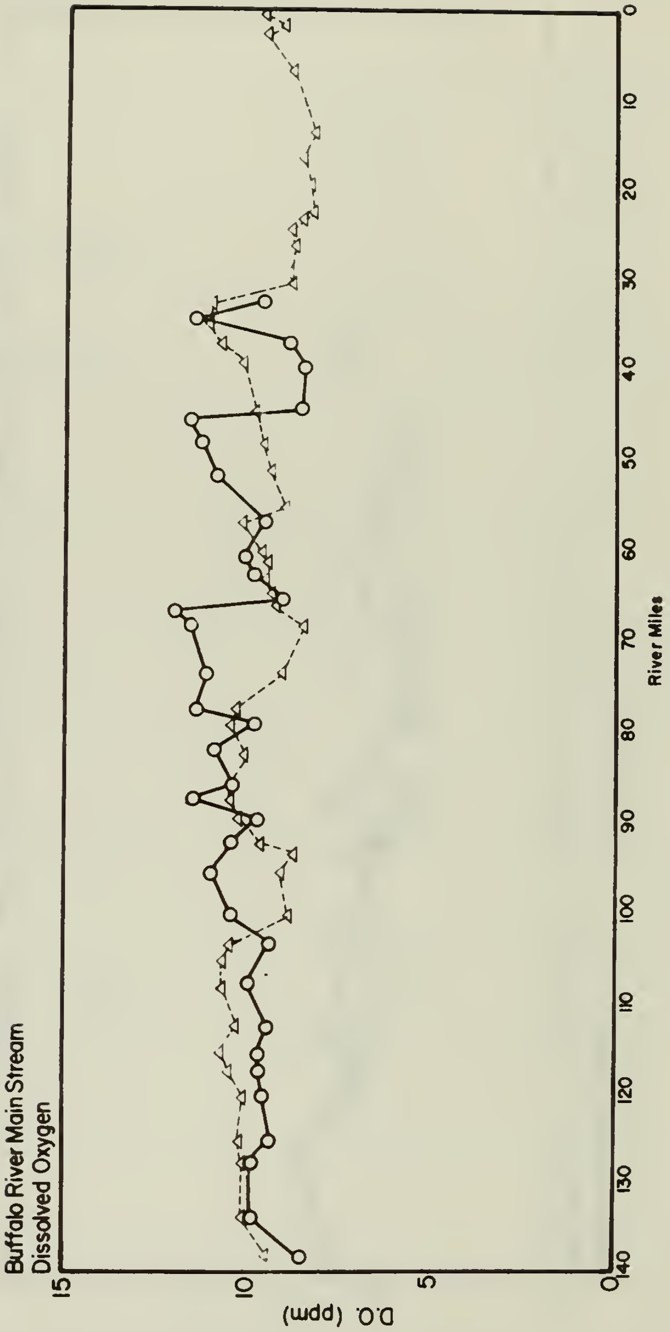

Buffalo River Main Stream
Dissolved Oxygen
D.O. (ppm)
15
10
5
0
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
River Miles

FIGURE 3

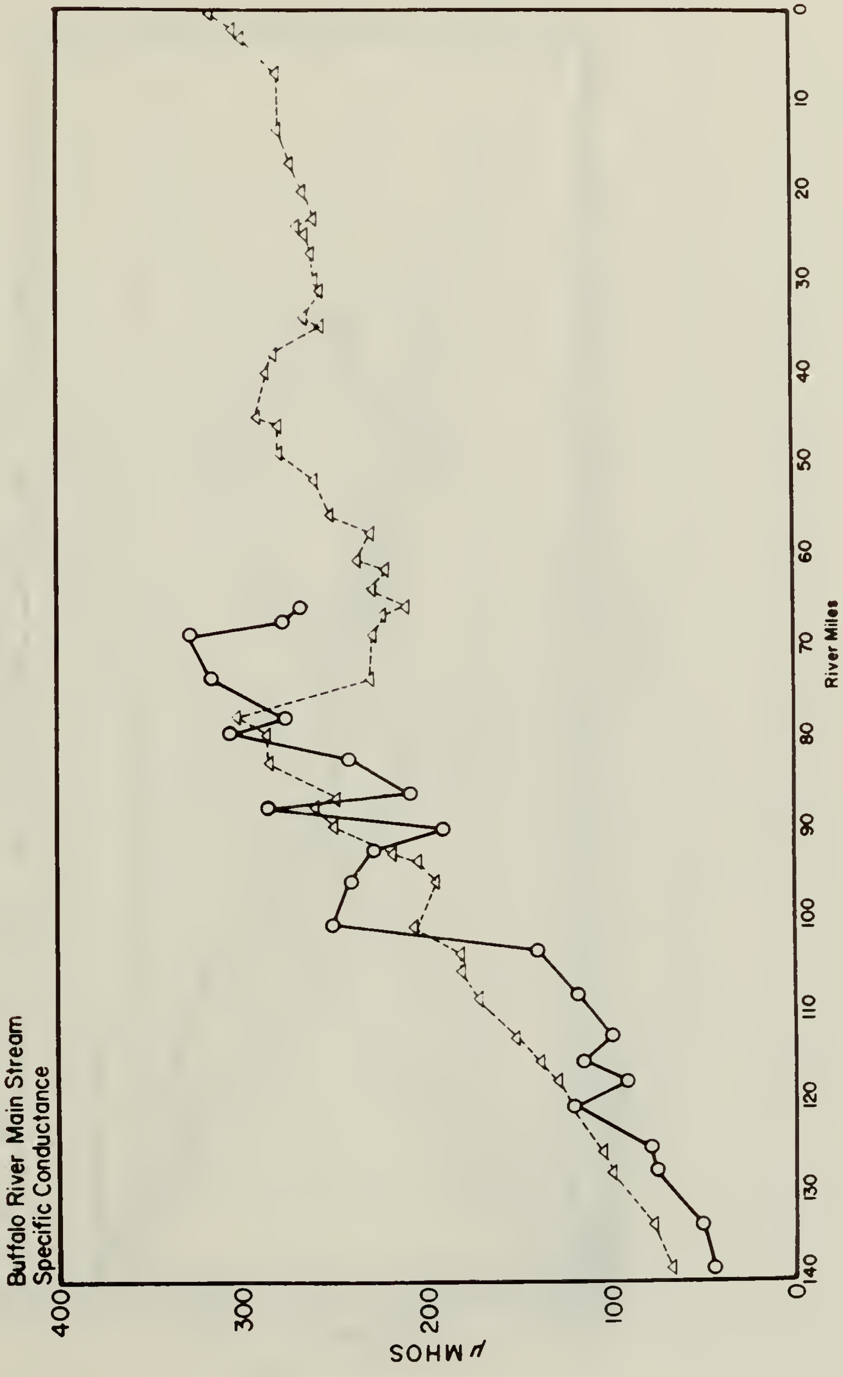

Buffalo River Main Stream
Specific Conductance
μ MHOS
400
300
200
100
0
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
River Miles

FIGURE 4

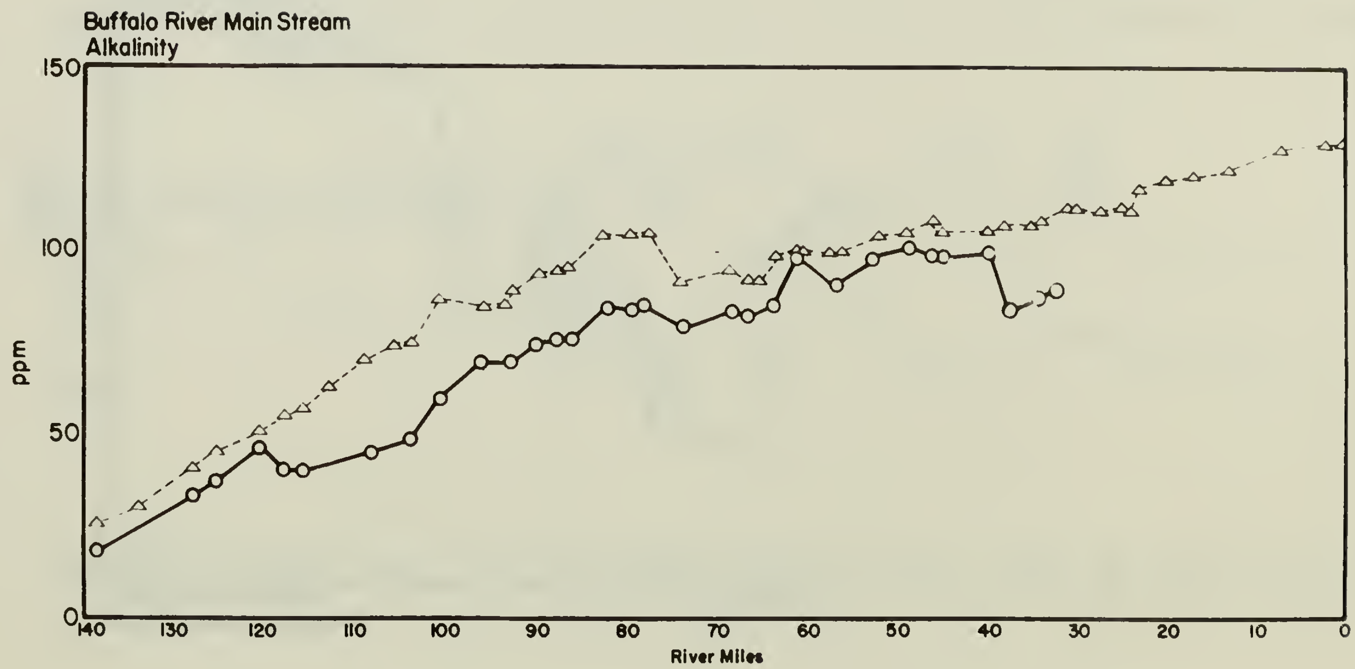

Buffalo River Main Stream
Alkalinity
ppm
150
100
50
0
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
River Miles

FIGURE 5

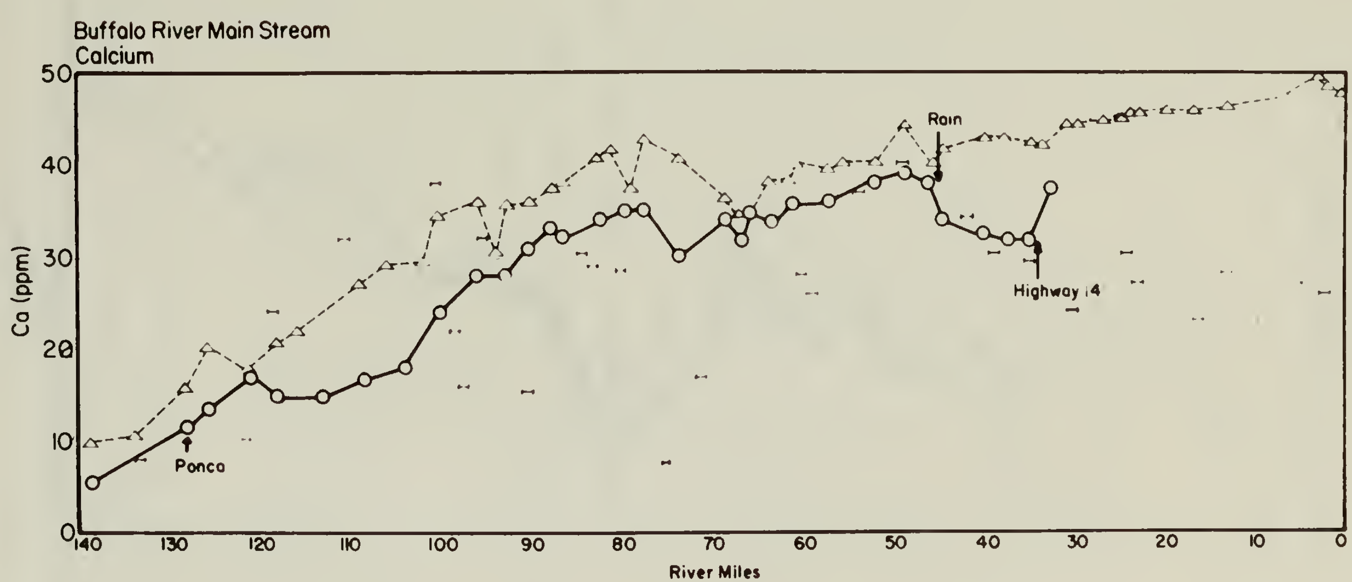
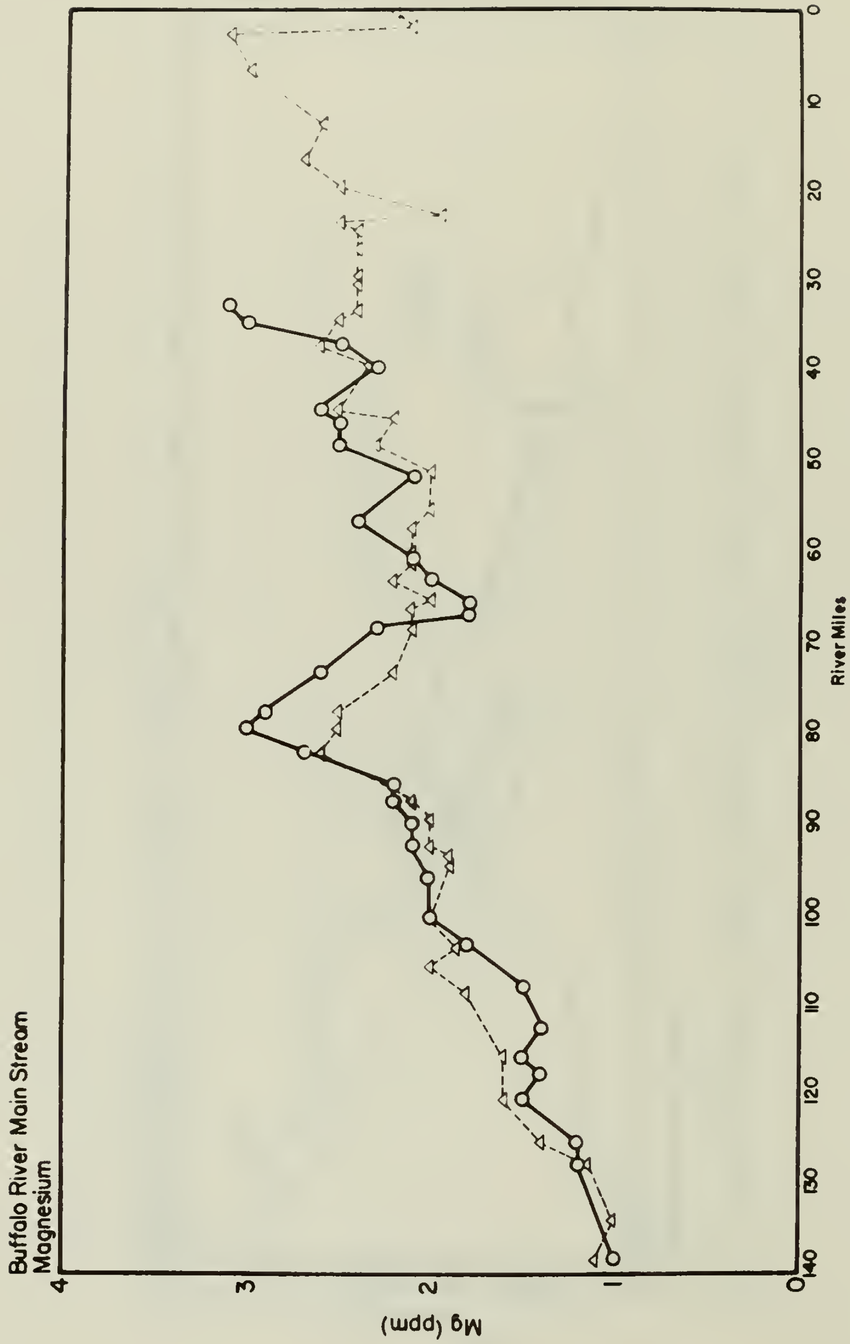

Buffalo River Main Stream
Calcium
Ca (ppm)
River Miles
Rain
Highway 14
Ponca
50
40
30
20
10
0
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

FIGURE 6



Buffalo River Main Stream
Magnesium
Mg (ppm)
0
1
2
3
4
River Miles
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

FIGURE 7

sandstone, shale, and limestone of a slightly younger age. The river continues through this formation for approximately 20 miles then re-enters the older formation of St. Peter Sandstone and Everton Limestone. The marked decrease of both calcium and magnesium throughout this section of the river indicates that limestone (and associated dolomite) is dissolving at a much slower rate than it is from the older formations.

The effect of these younger geological formations on the river is further shown by an inspection of the calcium concentrations of tributaries along the length of the river. In Figure 6, the calcium concentrations (divided by two so that they could be shown on the same graph) of tributaries are plotted as small horizontal bars at the river mile of their confluence with the Buffalo River. The tributary showing the lowest calcium concentration was Richland Creek, a major tributary of the Buffalo, which enters the river near river mile 76. Richland Creek, along with other tributaries in this same area, traverses the younger geological formations. From these data, it would appear that dilution from the tributaries in this section of the Buffalo River accounts for the observed break near river mile 80.

As shown in Figure 8, the calcium to magnesium ratio remains relatively constant throughout the length of the river. Only a slight increase in this ratio was observed in the upstream section of the river.

A comparison of the concentrations of sodium (Figure 9), potassium (Figure 10), and chloride (Figure 11) that were observed in 1973 and 1974 shows a marked difference. During the 1973 study, these parameters varied considerably throughout the length of the river. The 1974 study showed the concentration of sodium, potassium, and chloride to be essentially constant throughout the length of the river.

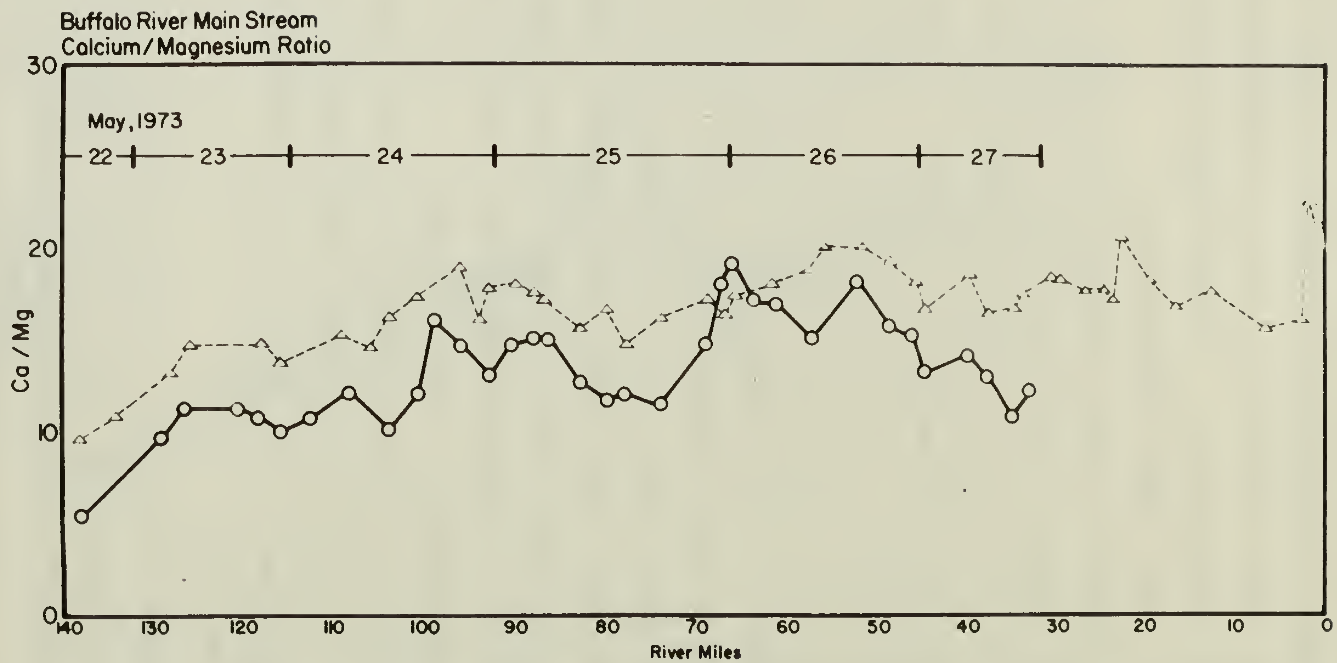

Buffalo River Main Stream
Calcium/Magnesium Ratio
May, 1973
22
23
24
25
26
27
Ca / Mg
30
20
10
0
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
River Miles

FIGURE 8

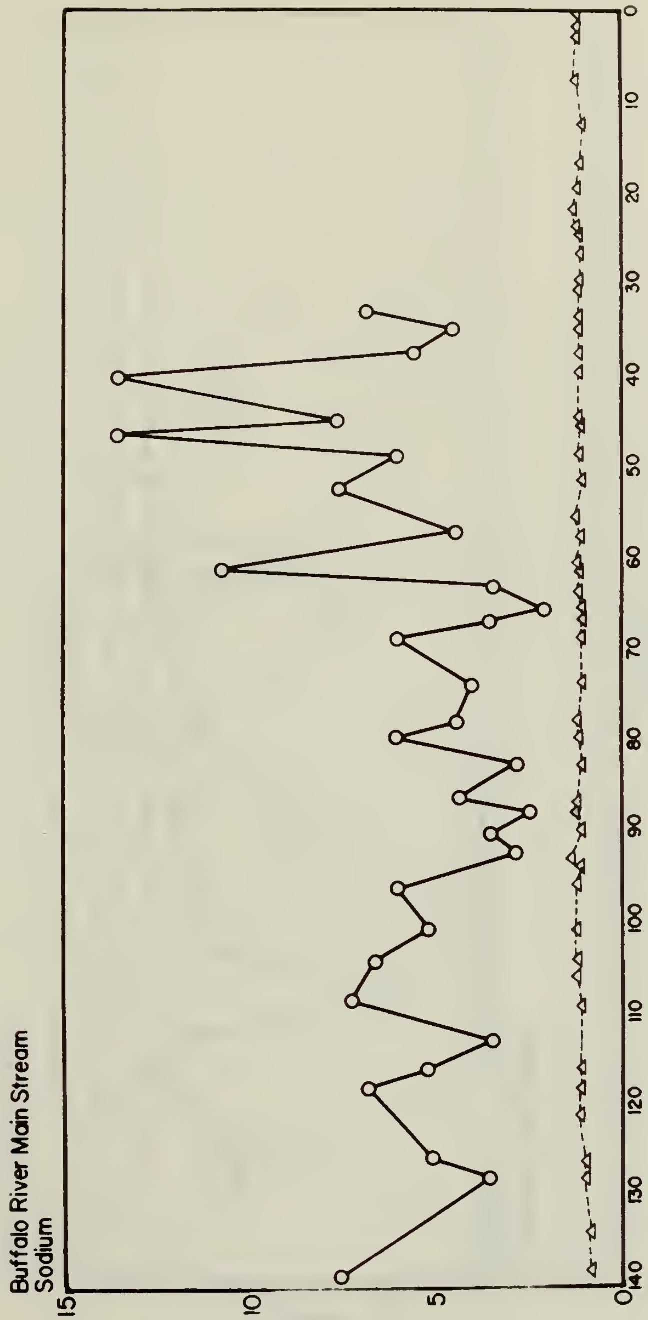

Buffalo River Main Stream
Sodium
Na (ppm)
15
10
5
0
River Miles
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

FIGURE 9

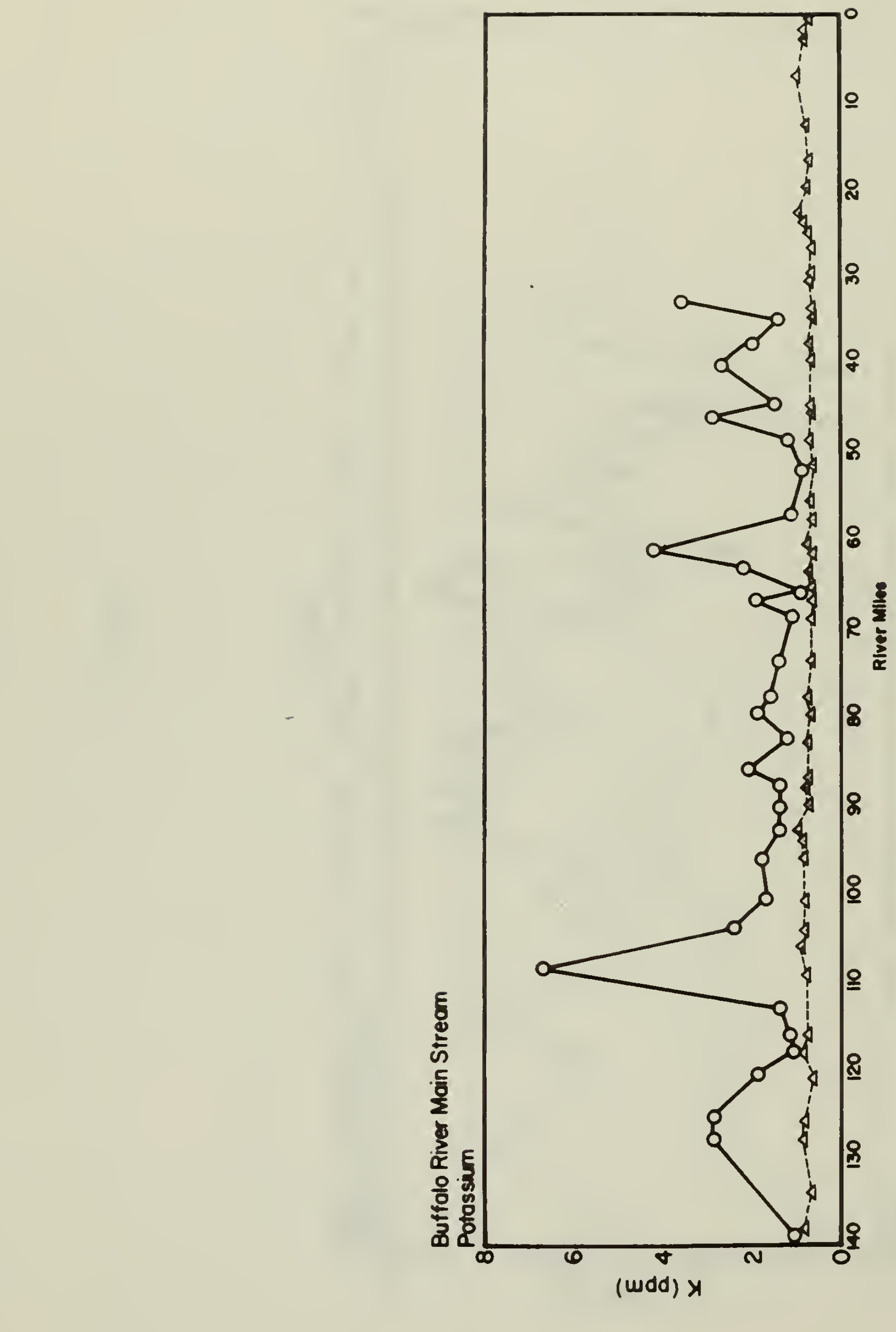

Buffalo River Main Stream
Potassium
K (ppm)
0
2
4
6
8
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
River Miles

FIGURE 10

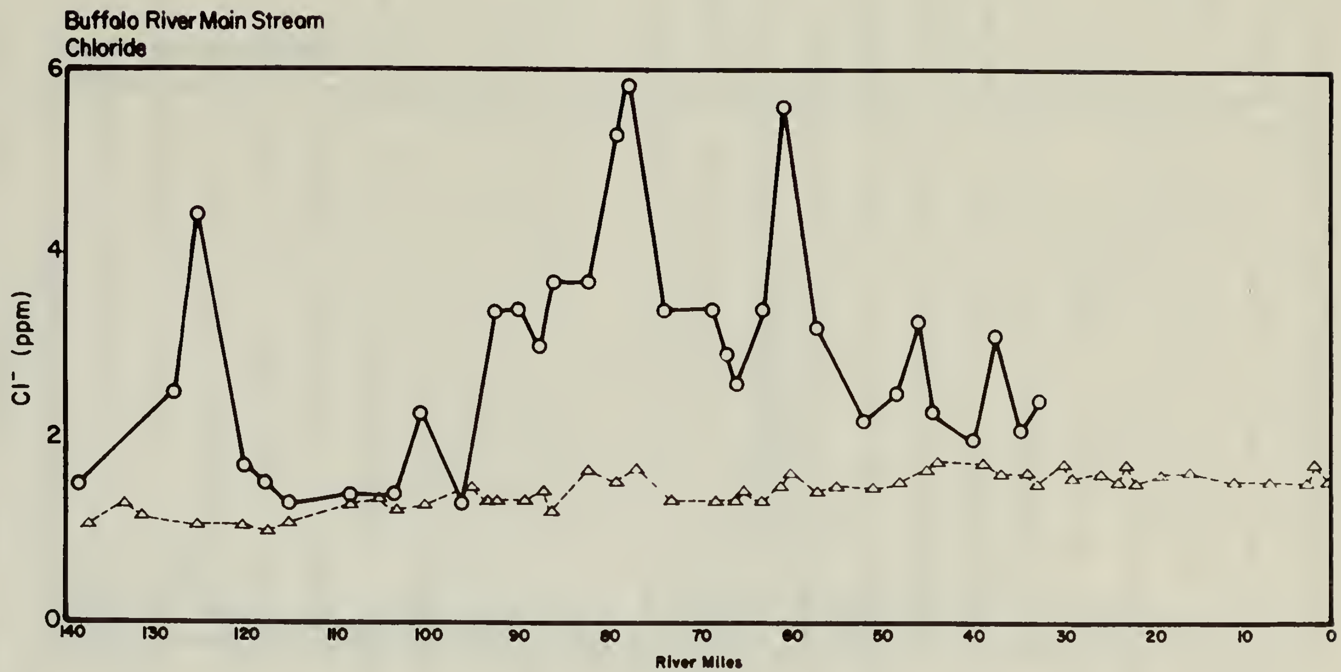

Buffalo River Main Stream
Chloride
Cl⁻ (ppm)
6
4
2
0
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
River Miles

FIGURE 11

Since rain showers were experienced throughout the watershed prior to and during the 1973 study, it is likely that the heterogeneous pattern observed for these constituents is produced by these constituents entering the river in surface runoff. The homogeneous pattern observed during the 1974 study may simply indicate that the river is approaching base flow conditions with essentially no runoff component. Cleaves et al. (6) have shown that some constituents which are easily leached from rock and soil in the vicinity of the river increase in the stream immediately following periods of runoff. Although it is impossible to determine the origin of these components in the river system from the data presented in this report, the data suggest that the origin of sodium, potassium, and chloride is very different from that of calcium, magnesium, and alkalinity. In fact, the levels of such constituents as sodium may reflect the activities of man.

The range of nitrate concentrations on the mainstream of the Buffalo River was similar to that observed in 1973. Two anomalously high points occurred near river mile 80 and a cluster of slightly higher points occurred between river miles 70 and 50. These anomalous values may indicate the presence of nitrate from agricultural activities. The fact that loading of nitrate (increase in a downstream direction) was not observed indicates that, although nitrate may be introduced at points along the river, the elevated concentrations are quickly dissipated, probably through biological activity.

Phosphate concentrations observed during the 1974 study wer significantly lower than those observed during 1973. The anomal peak near river mile 60 which was observed in 1973 was not confi by the 1974 study. As shown in Figure 13, there was a general t

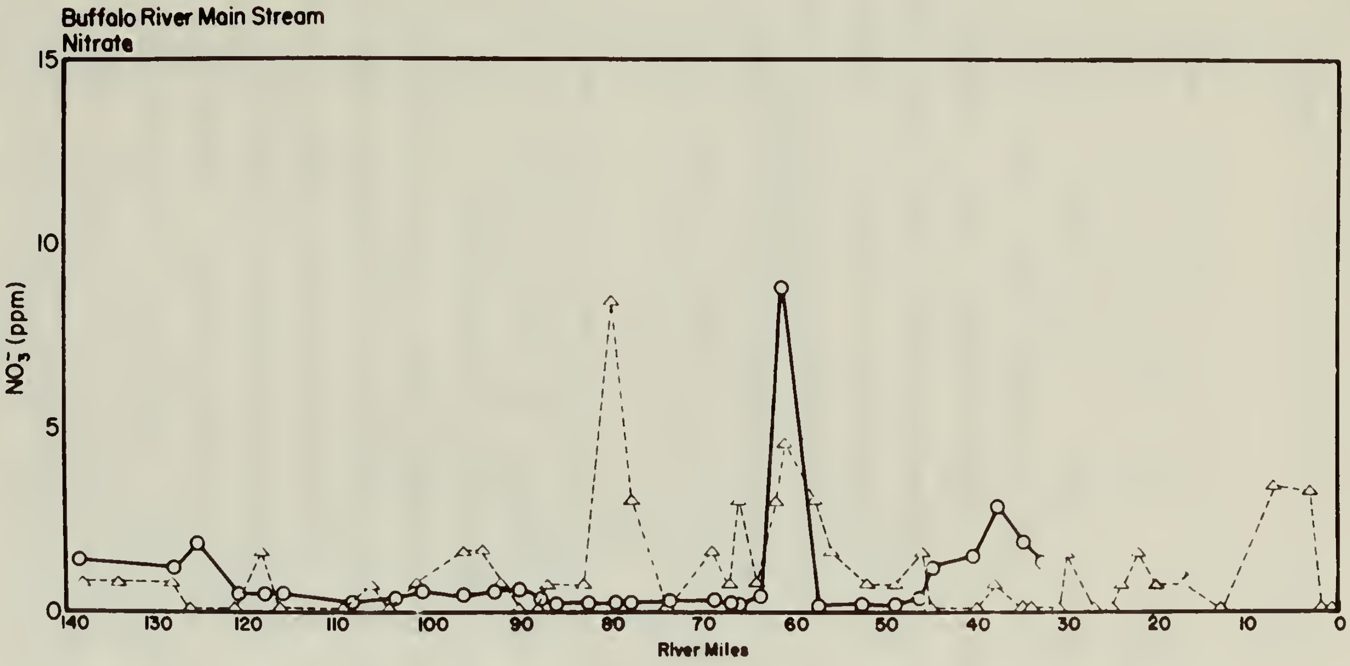

Buffalo River Main Stream
Nitrate
15
10
5
0
NO_3^- (ppm)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
River Miles

FIGURE 12

for phosphate to increase in a downstream direction. This loading in the downstream section of the river may originate from disturbed land throughout the watershed of the stream. The levels of phosphorus observed do not seem to indicate an excessive nutrient input.

Sulfate concentrations (Figure 14) were erratic but within a range similar to that observed in the 1973 study.

With the exception of one sample, the zinc concentrations observed in the Buffalo River were under 0.2 ppm. The presence of overburden and tailings from zinc mining operations throughout the Buffalo River watershed have been looked upon as possible sources of excessive concentrations of this heavy metal in the river. Even though zinc may be introduced, as is obviously the case at Rush Creek (0.17 ppm Zn), it is likely that this metal is quickly absorbed onto hydrous iron oxides, clays, or other minerals (7).

Iron concentrations were found to be extremely low during the 1974 study (Figure 16) with the only detectable iron being in the four samples in the headwater of the stream. Since the method used to measure iron (atomic absorption spectroscopy of a raw water sample) did not distinguish soluble from particulate iron, it is likely that the lower values indicate the absence of iron-bearing sediment which would be expected to be present following periods of high runoff.

In general, the chemistry of the Buffalo River seems to be responsive to the geologic environment and lateral inflow during periods of runoff. This study has demonstrated that concentration gradients exist throughout the length of the river and that the river responds to the particular geologic formation through which it flows. This study has also presented data that suggest that during periods of runoff, the river may become

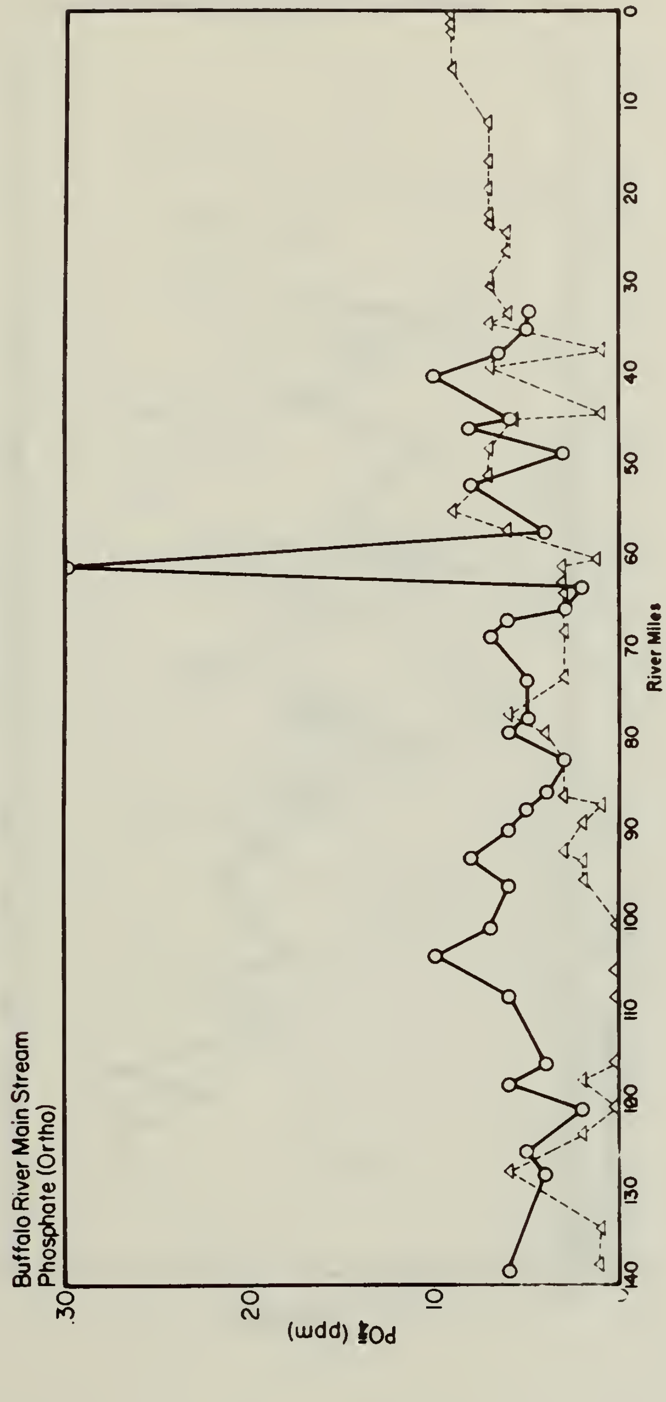

Buffalo River Main Stream
Phosphate (Ortho)
.30
20
10
PO_4 (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
River Miles

FIGURE 13

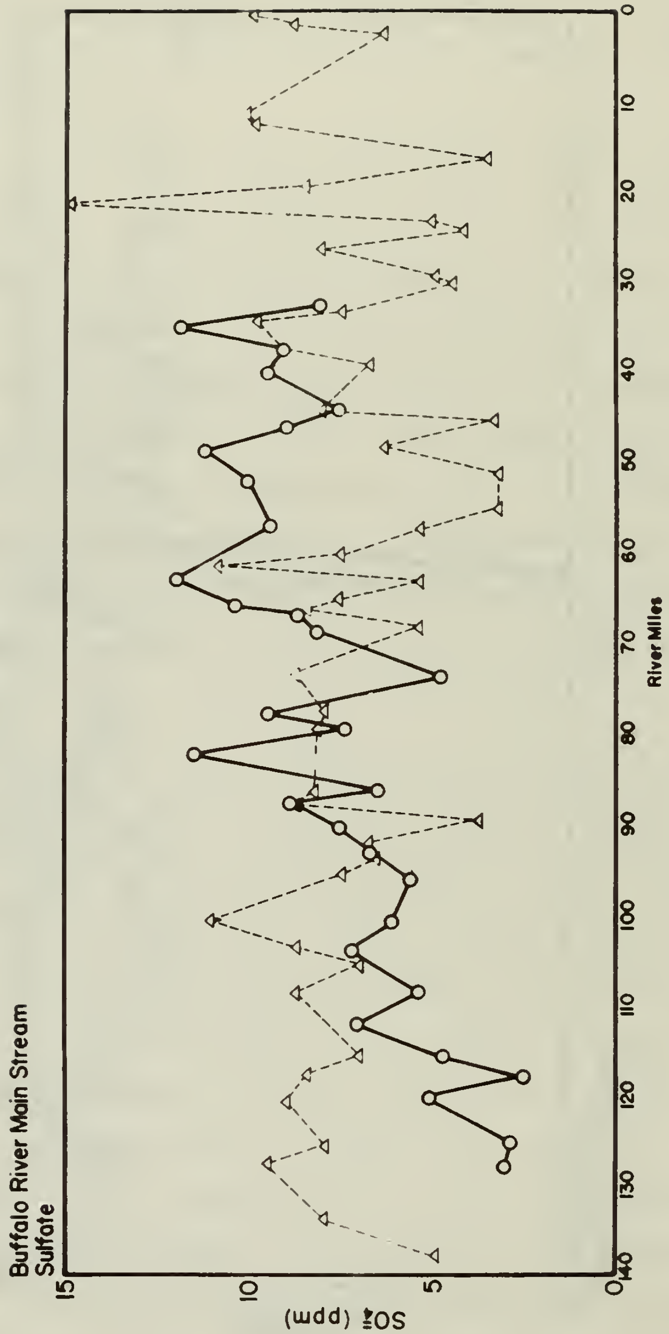

Buffalo River Main Stream
Sulfate
$SO_4^=$ (ppm)
15
10
5
0
River Miles
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

FIGURE 14

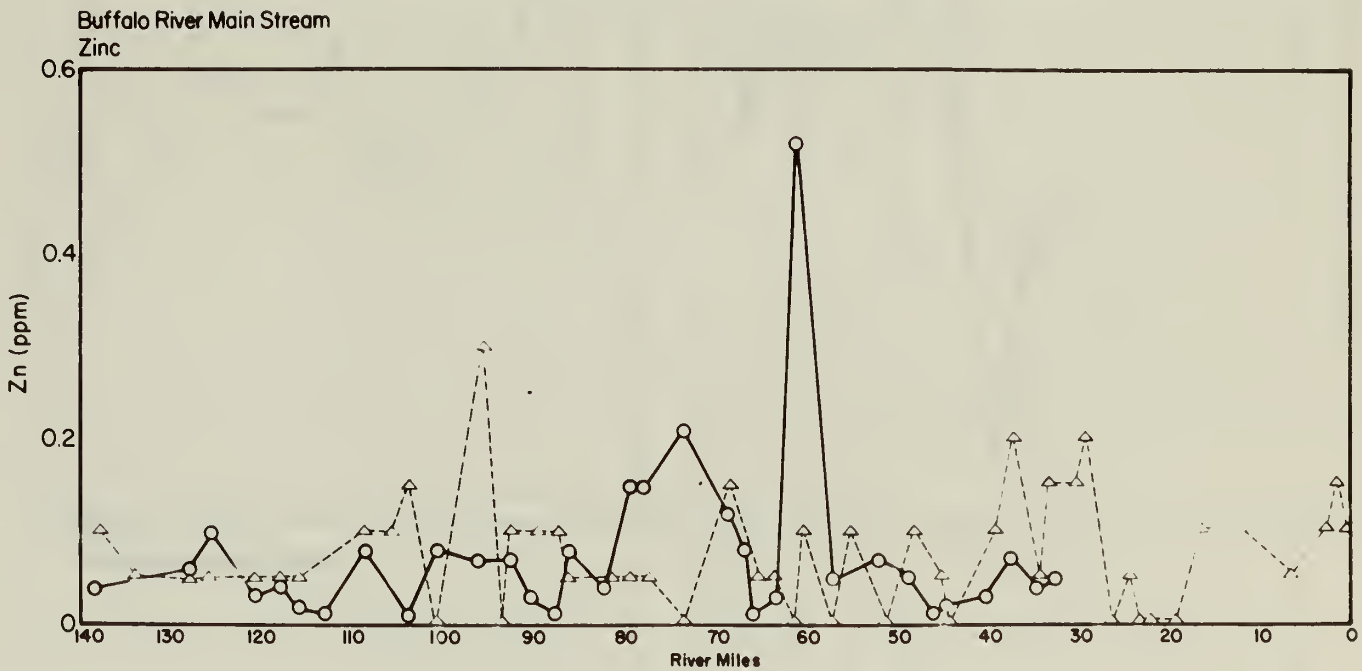

Buffalo River Main Stream
Zinc
Zn (ppm)
0.6
0.4
0.2
0
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
River Miles

FIGURE 15

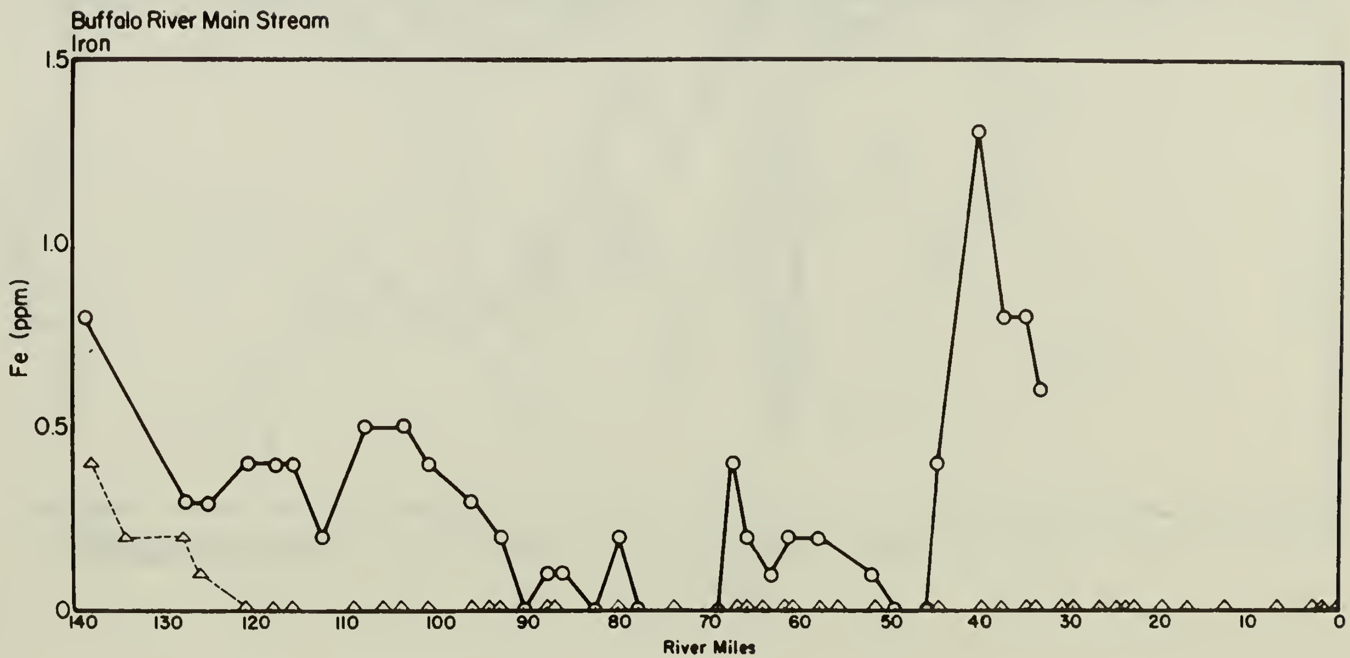

Buffalo River Main Stream
Iron
Fe (ppm)
1.5
1.0
0.5
0
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
River Miles

FIGURE 16

heterogeneous with constituents such as sodium and potassium and that these constituents may originate in the watershed immediately adjacent to the stream.

In an investigation of the Caddo River, Arkansas, Nix *et al.* (8) have studied the response of the river to a major storm event. Associated with significant increases in flow, some constituents were observed to increase while others clearly decreased in response to dilution. This study has demonstrated the dynamic nature of the Caddo River and suggests that grab samples taken from the river throughout the course of a year may be of only minimal value in determining seasonal cycling of chemical constituents in the river. In order to make a meaningful interpretation of any sampling program on the Buffalo River, some knowledge as to the response of the river to a storm event must be obtained.

Although the study of the Buffalo River presented in this report did not involve the determination of coliform bacteria, it should be mentioned that in the investigation of the Caddo River (8), fecal coliform changed from background values of 10 cells per 100 ml to around 5,000 cells per 100ml during the peak of the hydrograph. These authors suggest that the origin of the fecal coliform is cattle grazing in the immediate vicinity of the river.

GEOCHEMISTRY OF SEDIMENT AND WATER

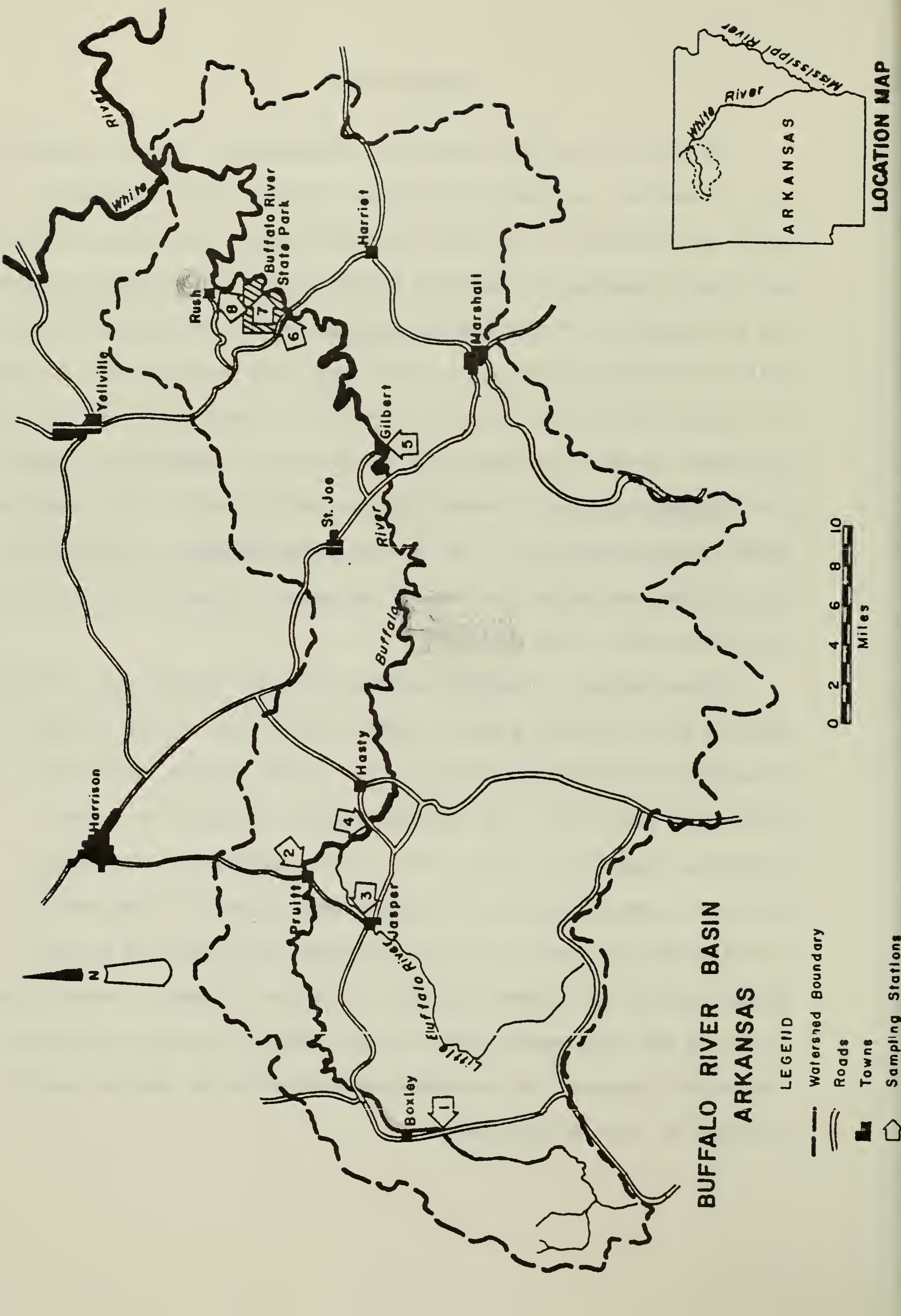
(Partial OWRT Funding)

Principal Investigator	Kenneth F. Steele
Research Associate	George H. Wagner
Research Assistant	William S. Bowen

INTRODUCTION

The Buffalo River flows generally northeasterly, draining predominantly shale, limestone, and chert in the upper drainage region and dolomite, limestone, and sandstone in the lower drainage region. Many inactive mines and mineral deposits of zinc, lead and some copper are scattered throughout the drainage area. Mining activity started in 1851 and was most active 1914 to 1917 but has been inactive for many years (McKnight (9)). Tailings piles near old mill sites still exist in a few places, such as at the confluence of Rush Creek where over 25,000 tons of concentrates, mostly zinc carbonate with small amounts of zinc sulfide and silicate, were produced. Lead mineral areas are mostly in the headwaters (Ponca-Boxley District) and the major zinc mineralized areas are along the lower portion of the river (Rush District).

Bottom sediment, suspended sediment and water samples were collected from the eight stations along the Buffalo River (Fig. 17) and selected tributaries on the following dates: 5/21-22/74, 6/17/74, 8/19-21/74, 12/20-21/74 and 3/6/75. The samples have been analyzed for sodium, potassium, magnesium, calcium, iron, nickel, manganese, zinc, copper, chromium, cadmium, colbalt and lead by atomic absorption spectrometry. Selected bottom sediments have been analyzed for mercury and arsenic. Because the bottom sediments contain the largest elemental concentration levels of the three sample types and yet contain extremely low mercury and arsenic contents, the suspended sediment and water samples were not analyzed for mercury and arsenic.


BUFFALO RIVER BASIN
ARKANSAS
LEGEND
Watershed Boundary
Roads
Towns
Sampling Stations
N
Harrison
Yellville
Rush
Buffalo River State Park
Harriet
Marshall
Gilbert
St. Joe
Hasty
Pruitt
Jasper
Boxley
White River
Buffalo River
Little Buffalo River
0 2 4 6 8 10
Miles
1
2
3
4
5
6
7
8
LOCATION MAP
ARKANSAS
White River
Mississippi River

BOTTOM SEDIMENTS

Sample Collection and Preparation

Bottom sediment samples were taken from the river bottom or bank generally just below the water line. The sediments were dried and sieved using a -95 mesh nylon screen. Petrographic analyses indicated the minus 95 mesh material was primarily quartz and chert with quartz predominating.

Several acid treatments of the bottom sediments were investigated (Wagner (10)). Treatment with aqua regia at room temperature was chosen as the standard treatment over other methods because of speed and the simplicity of the treatment. Most importantly it gave an amount considered sufficient to detect anomalous concentration of the heavy metals. Furthermore, aqua regia would be expected to dissolve all heavy metal sulfide grains, including cinnabar (HgS). In summary the standard acid treatment entailed treating one gram of minus 95 mesh fines with 2 ml of aqua regia (3/1 conc. HCl/HNO_3) for 13 hours at room temperature in a 50 ml glass-stoppered flask. At the end of 13 hours, 25 ml of deionized water was added to the flask, shaken well and filtered through a number 40 Whatman filter paper. The acid treated sediment was further washed three times with 5 ml portions of deionized water and filtered. All filtrate was collected in a 50 ml volumetric flask and finally diluted to 50 ml with deionized water. Two blanks were prepared in a similar manner for each series of samples. Sixteen of the samples were completely dissolved by hydrofluoric acid and analyzed. The amounts of the trace elements obtained by aqua regia extraction compared to the hydrofluoric acid total amounts with the exception that sodium and potassium are generally high, ranging from 30 to 100 percent (Table 25).

Table 25. Percentage of element extracted by aqua regia*.

Mn	Zn	Pb	Co	Fe	Cu	Ni	Mg	Cr	K	Na
105	95	92	77	71	66	54	51	28	4	3

* Compared with HF and averaged for 16 samples (Table A2).

Oxide coatings on the grains, and sulfide and carbonate clasts, are the most likely materials dissolved by aqua regia.

Although it is well known that the heavy metals are concentrated in the finer sediments (Hawks (11)), one set of analyses was made to establish this for the Buffalo River sediments. In Table 26 the acid soluble metal contents in two size fractions (one greater than 95 mesh and one less than 95 mesh) of a sample are compared. The plus 95 mesh fraction contains less of each metal which is consistent with a large amount of the metals being present in an oxide coating of the grains. A large grain would have a smaller surface area to volume ratio than a small grain.

Elemental Variation Along The River

Broad Sampling

The chemistry of the bottom sediments reflects the geology of the river. Data for this period, as well as other data, are given in Tables 27 and A1. Sodium and potassium are higher upstream (e.g., Fig. 18) probably due to small amounts of clay in the sediments, reflecting the shale environment. Iron and iron-associated elements (Cu, Co, Ni, Cr, Mn) are in the highest concentration upstream (e.g., Figs. 19 and 20). Shale is known to contain larger amounts of heavy metals than other sedimentary rocks and should make two contributions to the metal content of the sediments. Firstly, fine particles of shale, or clay from the shale, could be in the sediments. Secondly, the ground water upstream should have a higher concentration of dissolved metals and ferrous iron due to

Table 26. Effect of particle size on acid extraction analyses (ppm except Fe which is weight percent).

Sample	Na	K	Mg	Ca	Zn	Cu	Pb	Fe	Cd	Co	Cr	Ni	Mn
5, -95 mesh	40	172	826	2,740	306	4.0	5.8	0.724	2.07	4.9	4.0	6.4	175
5, +95 mesh	20	34	600	2,308	151	1.0	3.8	0.180	1.07	2.1	<.3	<1.0	57
	Parts/1000 Parts Fe*												
5, -95 mesh	--	--	--	--	--	0.59	0.62	--	--	0.62	1.4	1.2	17
5, +95 mesh	--	--	--	--	--	0.59	0.16	--	--	1.1	0.4	<1.0	21

* Aqua regia extraction values corrected to total metal on the basis of Table 28.

Table 27. Bottom sediment data for the Buffalo River and four tributaries* (ppm except Fe which is weight percent).

Station	River Miles	Na	K	Ca	Mg	Fe	Co	Cr	Ni	Cu	Zn	Cd	Mn	Pb
		Average values per station for nine sampling periods, March 1973 to March 1975.												
1	130	25	215	609	552	2.3	12	17	18	7	63	0.9	852	12
2	101	21	132	3053	398	1.2	6	11	11	4	76	1.4	355	13
3	104	36	191	3880	471	1.9	9	15	17	7	84	1.1	474	16
4	94.1	17	124	1598	412	1.3	7	9	11	4	73	0.9	361	11
5	55.2	7	104	2163	265	1.0	6	10	10	3	78	0.7	278	5
6	33.5	6	96	1779	625	0.8	5	10	8	3	133	1.1	209	9
7	31.4	9	93	1422	422	0.8	5	7	8	3	111	0.8	203	7
8	23.3	7	94	5099	1088	0.7	6	7	9	3	364	3.8	192	9
Rush Creek	23.5	17	74	12553	3379	1.3	8	5	9	7	2241	23.4	296	13
Clabber Creek	23.7	27	90	51346	5651	1.7	12	7	13	8	635	4.5	529	18
Ponca Creek	120	8	134	9881	464	2.2	11	12	17	5	990	3.5	828	106
Collection Date		Average values per collection date for eight stations												
5/22-23/73		6	185	1051	538	1.5	6	5	9	4	98	0.7	312	7
6/9/73		11	119	2587	420	1.1	6	10	8	4	112	1.9	321	8
6/24/73		75	115	4097	649	1.1	7	10	12	4	106	1.3	280	8
3/12/74		3	158	1823	514	1.6	7	11	13	4	70	-	534	3
5/22/74		12	137	2708	699	1.2	9	11	12	3	67	1.6	311	11
6/17/74		13	136	747	364	1.3	8	19	14	3	61	1.4	316	13
8/21/74		10	118	5528	465	1.0	6	9	11	5	60	1.0	472	15
12/21/74		6	44	1819	638	1.3	8	11	12	5	374	2.2	388	14
3/26/75		10	167	1696	476	1.4	7	10	14	6	157	0.7	356	13

* Tributaries include Station 3 (Little Buffalo River)

KEY TO SYMBOLS FOR FIGURES 18 - 21

Samples collected 5/22-23/73

Samples collected 6/9/73

Samples collected 6/24/73

Samples collected 3/12/74

Samples collected 5/21-22/74

Samples collected 6/17/74

Samples collected 8/19-21/74

Samples collected 12/20-21/74

Samples collected 3/6/75

Average of all samples at each station

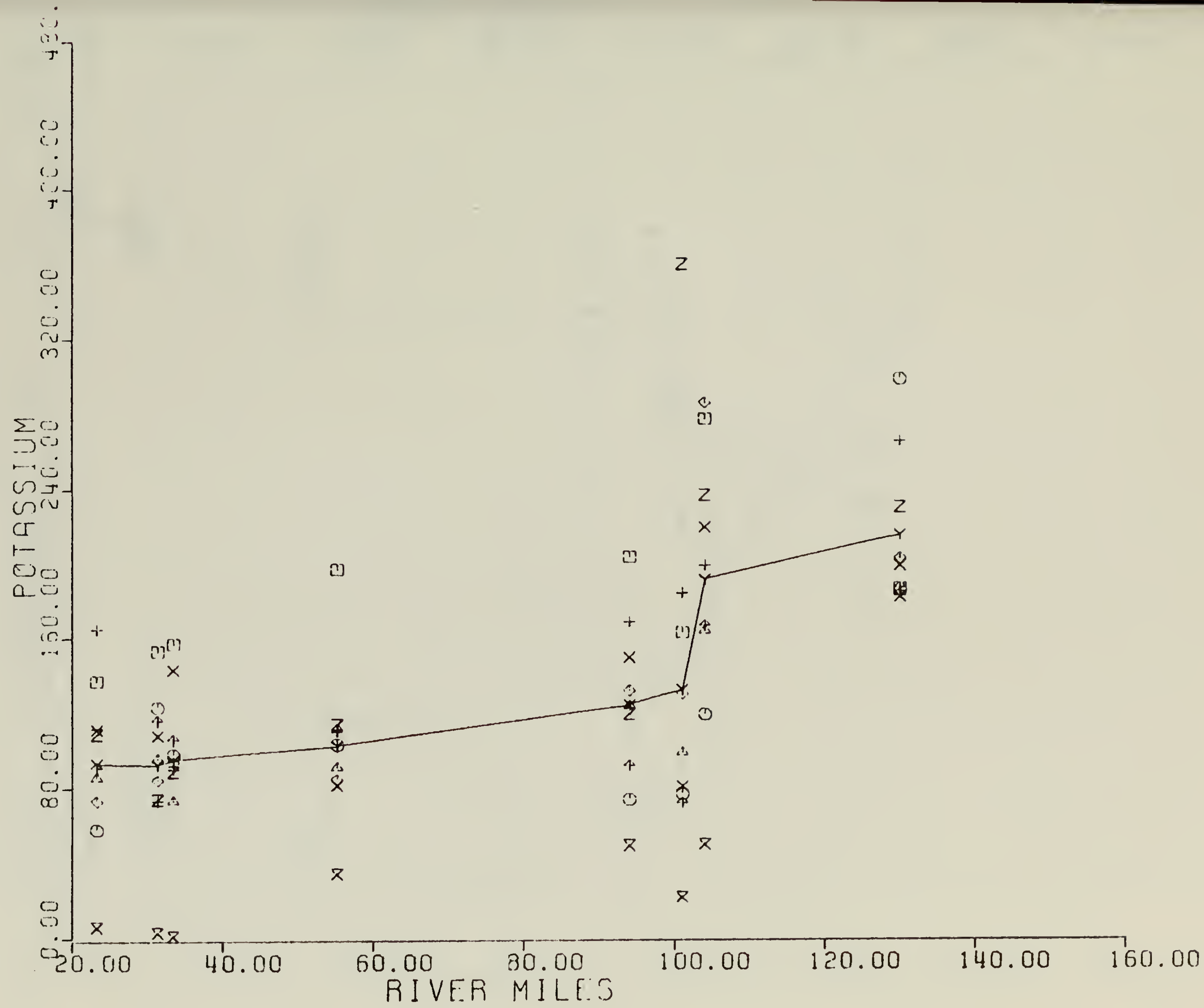
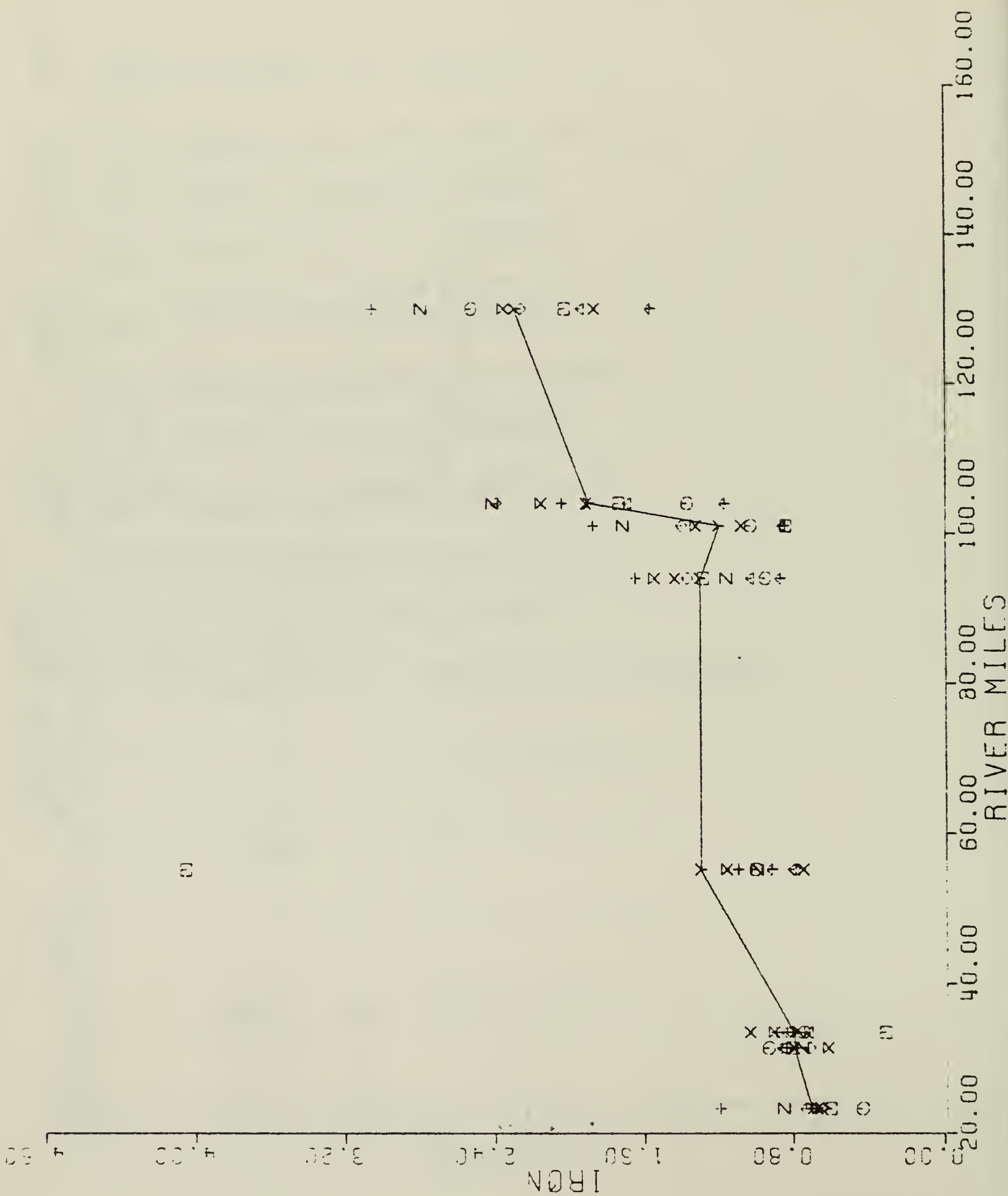


FIGURE 18. K VS RIVER MILES (BOTTOM SEDIMENTS).


RIVER MILES
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
IRON
0.00
0.80
1.60
2.40
3.20
4.00
4.80

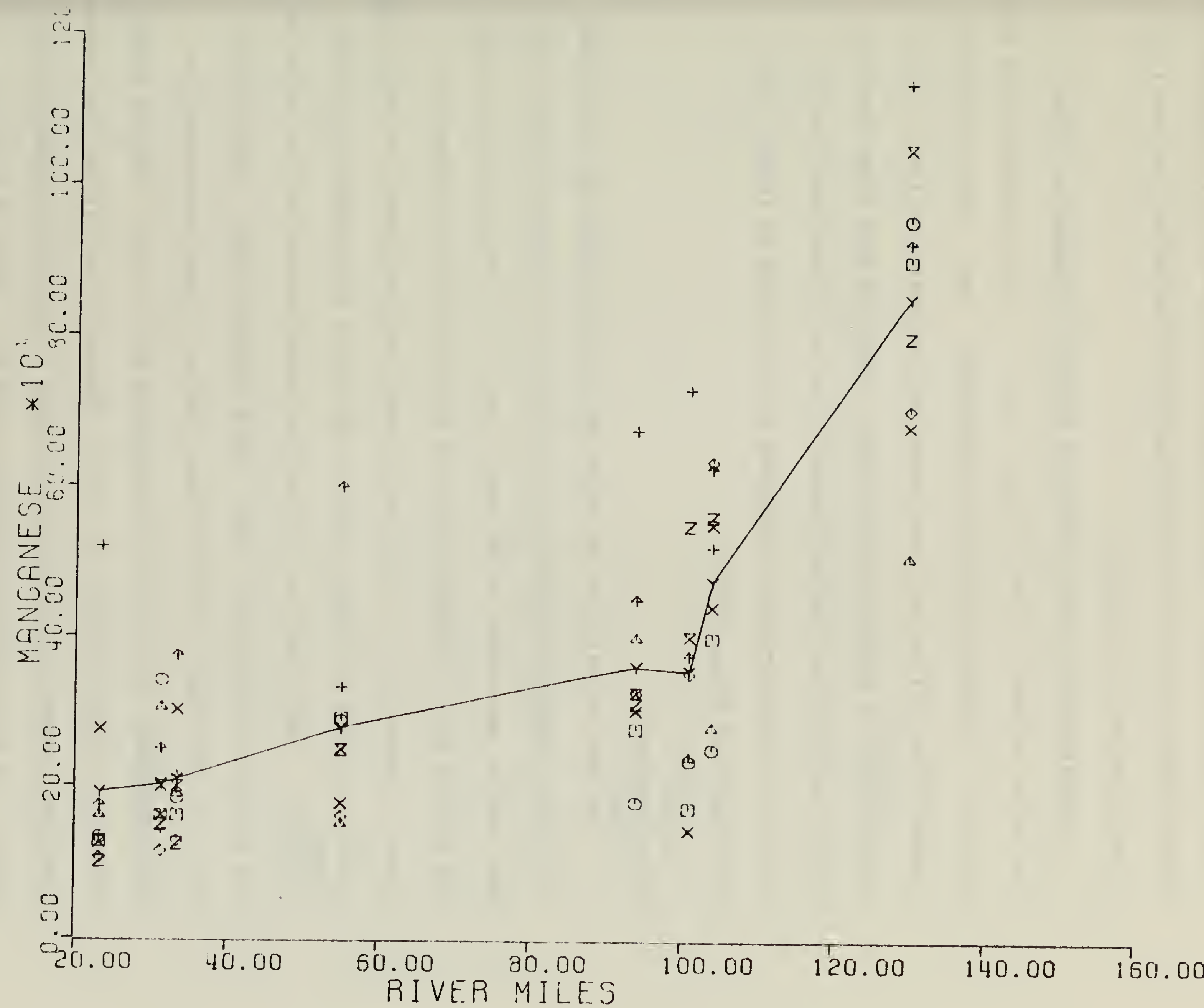


FIGURE 20. MN VS RIVER MILES (BOTTOM SEDIMENTS).

contact with more shale. When oxidation occurs the iron is deposited as hydrous ferric oxide on the stream sediments along with other metals by coprecipitation and sorption.

Downstream the concentrations of calcium and magnesium contents of the bottom sediments increase (e.g., Fig.21). This is expected from the increase in limestone and dolomite downstream. Lead, zinc, and cadmium concentrations follow the known mineralogy and mining activity - lead concentration is greatest upstream where there are more known lead deposits, and zinc and cadmium concentrations are highest near the Rush Creek zinc mining area and downstream from it (Table 30) (Wagner, 1974, and Steele and Wagner, 1975).

Close Sampling

The lower 60 miles of the river was closely sampled on July 20 and 31, 1973. Particular attention was given to all tributaries where sediment samples were taken on the downstream side of their confluence with the Buffalo River. Chemical data and locations for these samples are given in Wagner (10). Extractable zinc, lead and copper for these sediments are plotted in Figure 22 against the sum of extractable calcium and magnesium. Peak values for calcium plus magnesium and for zinc occur at two old zinc mining areas, Kimball Creek and Rush Creek. Lesser peaks occur on each side of the major ones with fairly good concordance between the peaks for calcium plus magnesium and for zinc, lead and copper. These peaks occur also more or less in phase with the calcium plus magnesium peaks, probably because mineralization is favorable in the dolomitic rocks. Old mill tailings at Kimball Creek and Rush Creek may also be

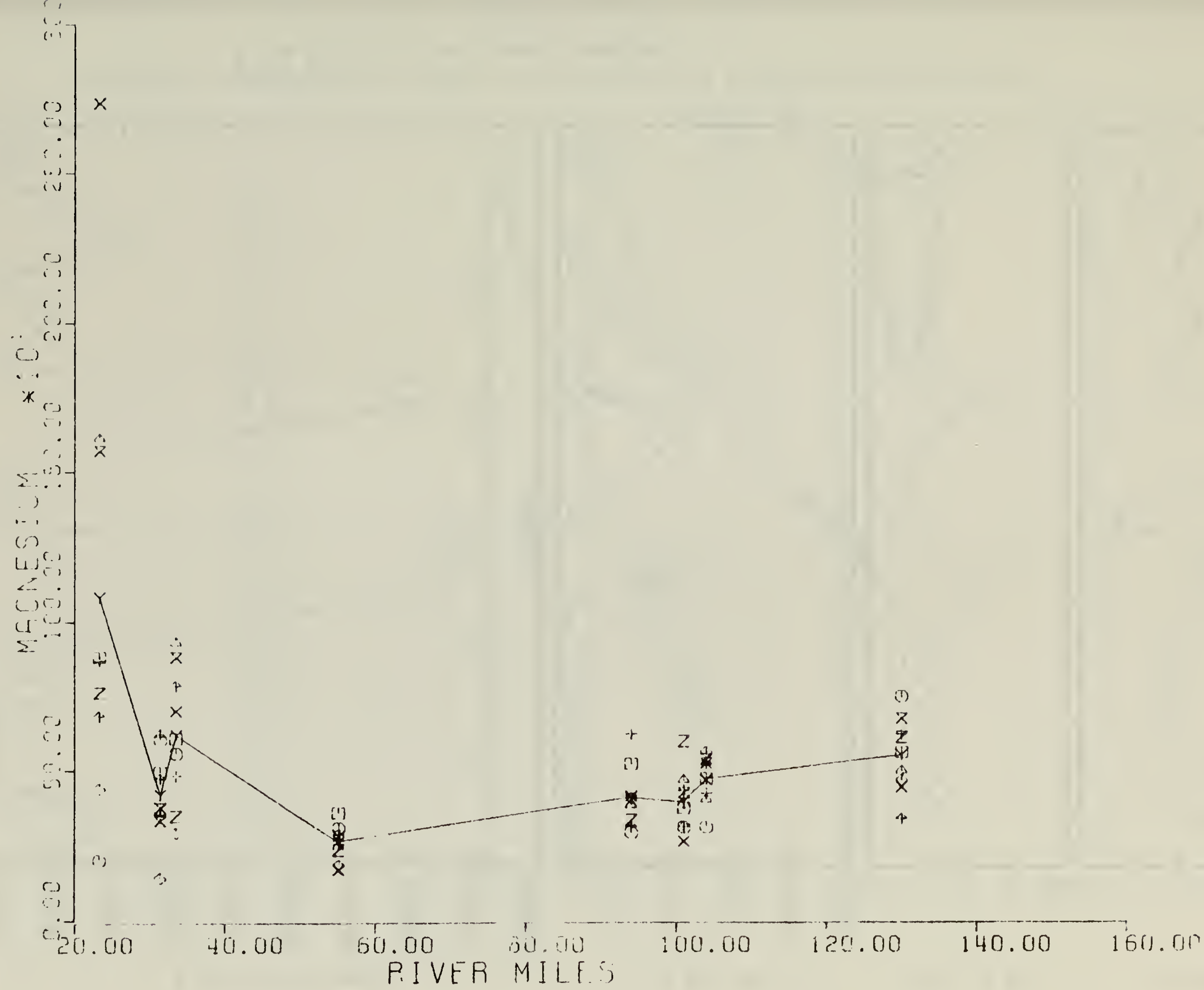


FIGURE 21. MG VS RIVER MILES (BOTTOM SEDIMENTS).

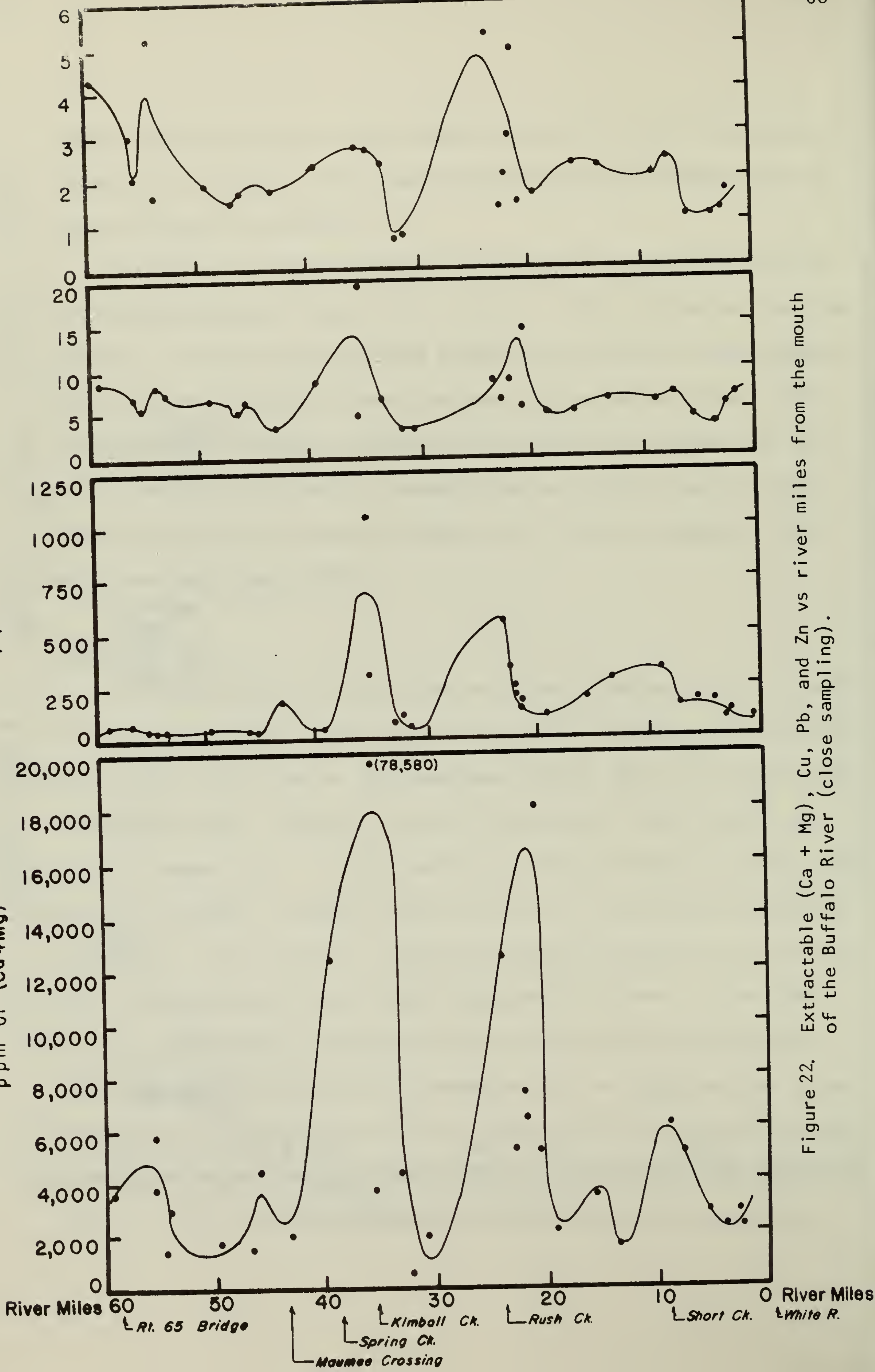


Figure 22. Extractable (Ca + Mg), Cu, Pb, and Zn vs river miles from the mouth of the Buffalo River (close sampling).

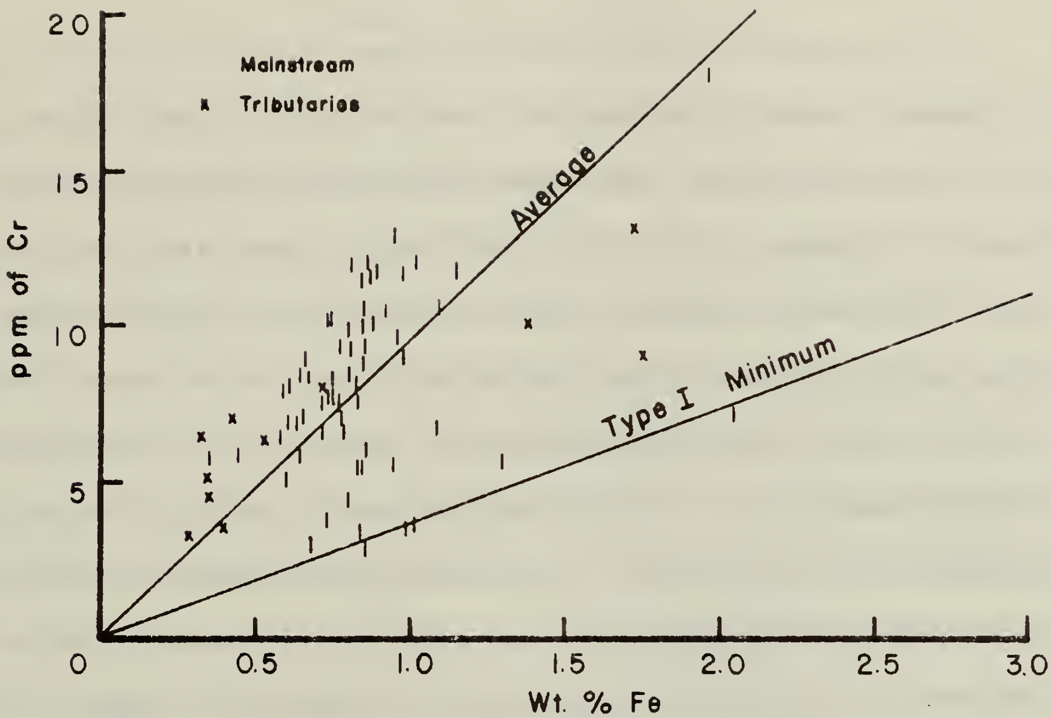


Figure 23. Extractable Cr versus extractable Fe. Length of the bar and size of x reflect uncertainity in data.

influential. Peak values of metals can return to background values within a mile. This results because the unique sediments from a tributary give high values near the mouth but are diluted further along the main river by less unique sediments of the main channel.

Grain Chemistry

Our previous data and discussions have focused on the river bed as a chemical system. The chemistry and mineralogy of the sediment grain will now be discussed. The extractable amounts of potassium, magnesium, cobalt, manganese, chromium, nickel, lead, copper, zinc, and calcium were individually plotted against the extractable amount of iron in the same sample of minus 95 mesh sediment. Data from 77 samples collected 2/4/73, 7/20/73 and 7/31/73 were used. Samples taken in a tributary were plotted separately. Tributary samples were taken about 100 yards upstream into the tributary. All of the elements exhibit a linear relationship with iron concentration - an increase in iron concentration yielded an increase in element concentration. A typical plot exemplified by Figure 23 for chromium shows a minimum and average line. Very high concentrations of the non-iron metals which are well above the average are believed to be due to mineral clasts of these elements in the sediments. This occurred with magnesium, calcium, zinc, cadmium, copper, and lead. All of these have mineral occurrences in the Buffalo River drainage area. The minimum to average values are believed to be associated with a hydrous iron oxide coating on the sediments. Thus for magnesium, calcium, cadmium, zinc, copper, and lead it is proposed that they exist and are transported as clasts, as well as in the oxide coating of the

sediments. These metals exist in mineral clasts primarily in the low iron, high calciferous environment which is the more mineralized area of the Buffalo River. Other metals studied here, cobalt, manganese, chromium, nickel, and potassium, are apparently carried in the ferric oxide film with no evidence for clasts.

Comparison With Average Rocks

The anomalously high values for each element are summarized in Table 4 and compared to average values for the sedimentary rock types, shale, sandstone and carbonate. Only a cross section of the samples representing the main length of the river were analyzed for arsenic and mercury. Samples from Kimball Creek, Clabber Creek and Rush Creek were included because they are from zinc mining areas and had high zinc values. Enargite (Cu_3AsS_4) has at least one occurrence in northern Arkansas. Two of these three samples from the zinc mining areas had somewhat higher arsenic values but lower than that found in the shale district at Boxley. Only a few representative samples were analyzed for mercury and arsenic (Table 29) because of the special treatment that they required (Steele et al., (13); Wagner (10)). The overall range for arsenic was only 5-14 ppm. Mercury has a range of 0.02-0.049 ppm with the higher values at Boxley, Ponca and Jasper in the shale and lead mineralized area. It will be noted that of the three rock types, shale has the greatest amount of each metal, except manganese which is greatest in carbonate rocks.

Only three of the metals, zinc, lead and cadmium, have high ranges in the sediments well above that for an average shale. The high values

Table 28. Comparison of heavy metals in Buffalo River bottom sediments with those in average rocks (ppm except Fe which is weight percent)

Element	Shale*	Sandstone*	Carbonate Rocks*	High Range In Sediments	No. of Samp in High Ran
Zn	95	16	20	300-4000	14
Cu	45	1-10	4	8-9.2	2
Pb	20	7	9	14-357	7
Cd	0.3	0.01-0.1	0.035	2-34	21
Co	19	0.33	0.1	10-18.4	5
Ni	68	2	20	15-20	5
Cr	90	35	11	13-23	4
Mn	850	10-100	1,110	500-956	5
Zr	160	220	19	600-2820	5
As	13	1	1	11-14	3
Hg	0.4	0.03	0.04	0.02-0.05	3
Fe	4.72	0.98	0.38	2-2.52	2

* From Turekian (14).

Table 29. Arsenic and mercury in Buffalo River bottom sediments.

Location	River Miles	ppm of Arsenic HCl Extraction	ppm of Arsenic Aqua Regia Extraction	ppm Mercury
Boxley	130	14	7	0.023
Ponca	125	--	-	0.028
Pruitt	101	--	6	0.013
Jasper*	104	--	4	0.049
Hasty	94	9	7	0.017
Gilbert	55.2	7	4	0.010
Kimball Creek	35.5	9	-	--
Hwy. 14 Bridge	33.5	5	4	0.017
State Park	31.4	5	4	0.013
In Clabber Creek	23.5	--	12	--
Rush Creek	23.7	11	6	0.011

* On tributary, Little Buffalo River.

of 300-4000 ppm for zinc were all obtained in sediments at the confluence of tributaries draining old mining areas or known mineral deposits. Background values for zinc in the sediments were 50-200 ppm with the higher background values occurring in the lower one-third of the river which is just beyond Rush Creek, the principal zinc mining area. Cadmium values were on the average 8-10 parts per 1000 parts of zinc, the same ratio which is found in the ores (McKnight, (9)). Thus cadmium highs corresponded to highs for zinc. Because of this constancy between cadmium and zinc it was concluded that they were transported as mineral clasts in the river. Lead background values were from 4-10 ppm as against the high range of 14-357 ppm found at the confluence of tributaries draining lead mining areas. These tributaries were in the headwaters of the Buffalo River in the Boxley-Ponca area. Perhaps attention should be given to ensuring stabilization of ore and tailings piles in these old lead and zinc mining areas in order to minimize pollution of the Buffalo River sediments.

Ponca-Boxley Lead District

In order to better delineate element relationships in the upper part of the Buffalo River, bottom sediments were collected in the Ponca-Boxley Lead District on 1/18/75. Bottom sediment samples were taken in ten selected tributaries (Fig. 24) upstream from their confluence with Buffalo River. Additionally sediment was collected in the river above and below these points of tributary confluence, except no upstream samples for Moore and Running Creeks were collected. Two of the tributary (Adds and Ponca) samples were obtained upstream of the town of Ponca (site of the old mill).

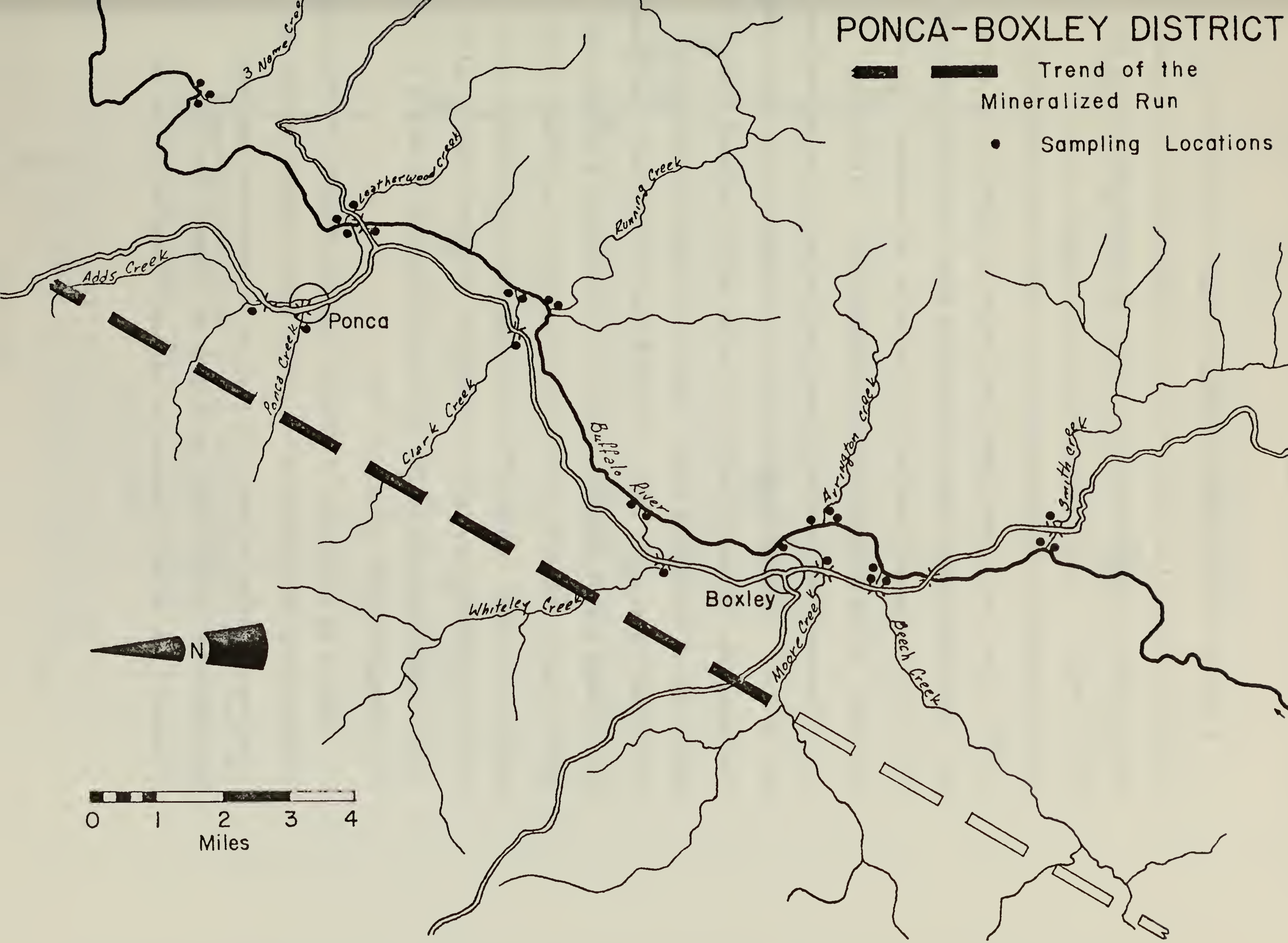


Figure 24. Detailed map of Ponca-Boxley Lead District showing mineralized trend and sample locations.

A plot of Pb concentration of bottom sediment from the river and tributaries versus river miles (Fig.25) corresponds well with reported mineralization. The tributary values from the mineralized side of the Buffalo River are significantly higher than those from the non-mineralized side and values from the river. There are two anomalously high Pb values. One is from 3-Name Creek which is located on the south-east ("non-mineralized") side of the Buffalo River. The other anomalous Pb value is from Beech Creek which is located on the northwest side of the river. If the mineralized zone of McKnight (9) is extended across the watershed, then Beech Creek should be part of the mineralized zone (Fig.24). Although Whiteley Creek and the upper part of Ponca Creek (upstream from the town of Ponca) are located on the northwest ("mineral-ized") side of the Buffalo River, they have no reported mineralization within their watersheds. This is confirmed by the relatively low Pb con-tent of their bottom sediment (Fig.25). It is interesting to note that the Pb values at the mouth of Ponca Creek are higher than either of the two values obtained upstream from the town of Ponca (Table 30). This can be interpreted as evidence of additional, unreported mineralization or more likely as contamination from the tailings pile at the old mill just upstream from the collection site.

There is no systematic variation of lead concentration of the bottom sediments along this portion of the Buffalo River; however, many of the tributaries, whether draining a mineralized or non-mineralized area, contain greater concentrations of many of the elements (Table 30). Dilution of the unique (element-rich) sediments from the tributaries

Figure 25. Pb vs river miles from Smith Creek (SM) in the Ponca-Boxley District.

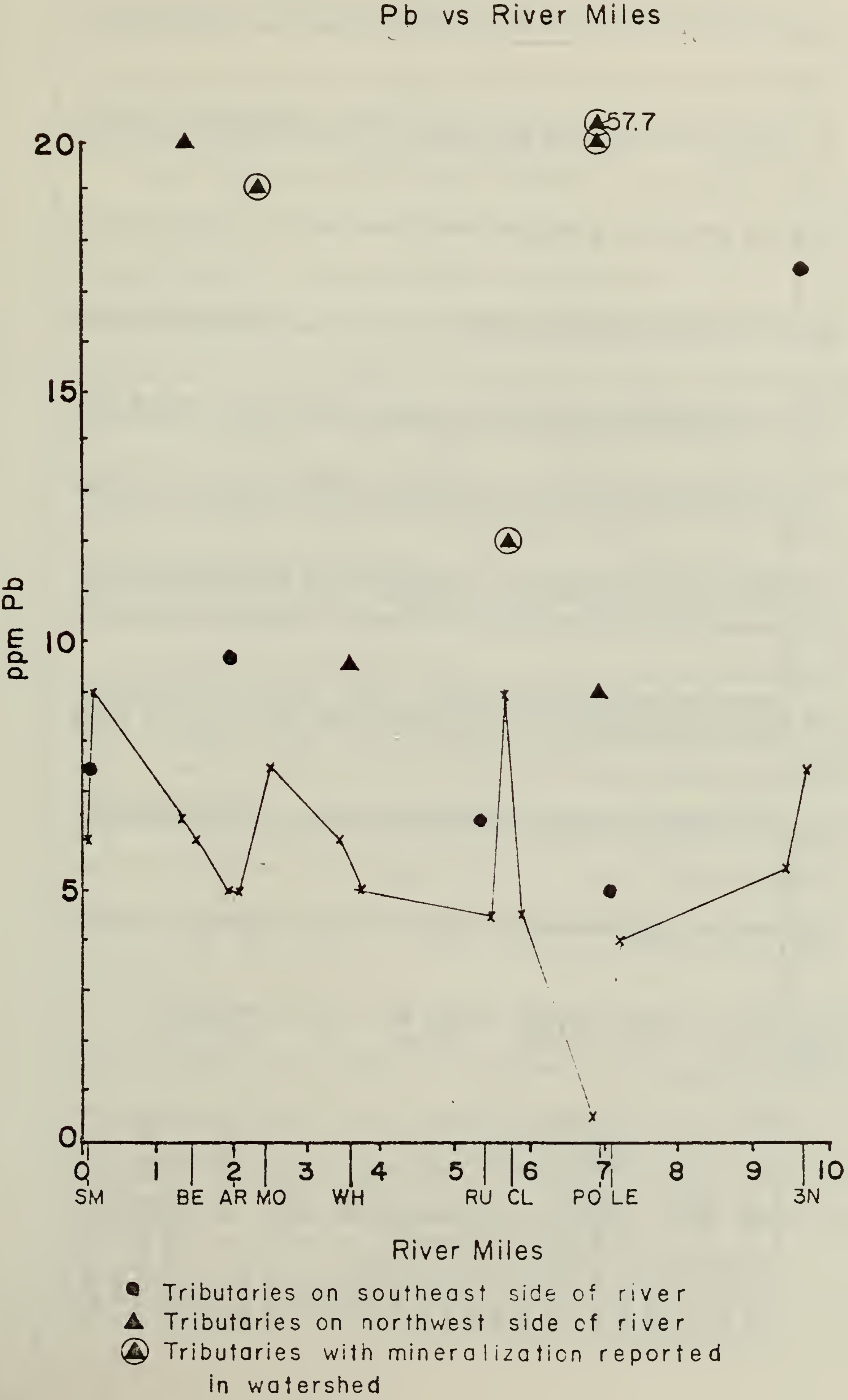


Table 30. Analyses of bottom sediment samples from the Ponca-Boxley District. River miles are measured from Smith Creek. All values are ppm except Fe which is weight percent.

	River Miles	Pb	Zn	Cd	Fe	Co	Cr	Ni	Cu	Mn	Mg	Ca
Smith Ck (A)		6	48	0.85	2.22	13	17	18	8	1000	575	260
Smith Ck	0	8	73	1.30	2.48	19	21	29	14	1147	787	3500
Smith Ck (B)		9	63	0.85	2.61	13	21	24	10	1000	637	465
Beech Ck (A)		7	48	0.85	1.80	11	16	21	7	812	425	260
Beech Ck	1.5	20	216	1.00	2.20	13	17	19	14	900	575	470
Beech Ck (B)		6	56	0.85	2.42	13	19	23	8	975	587	320
Arrington Ck (A)		5	63	0.85	2.21	14	19	22	7	950	512	465
Arrington Ck	2.0	8	85	0.65	2.91	21	27	30	14	1500	725	2500
Arrington Ck (B)		5	65	0.50	2.48	16	25	22	9	1175	550	1150
Moore Ck	2.4	19	65	1.70	2.12	17	18	29	16	850	600	7500
Moore Ck		8	84	0.85	2.61	16	23	24	10	1062	612	745
Whiteley Ck (A)		6	62	0.65	2.21	14	20	20	5	1125	550	710
Whiteley Ck	3.6	10	52	0.85	2.20	14	18	21	5	1025	712	5000
Whiteley Ck (B)		5	58	0.65	2.30	16	15	19	5	1550	487	475
Running Ck	5.4	7	67	1.0	2.66	19	25	25	10	1125	687	5000
Running Ck (B)		5	69	0.65	2.26	14	21	24	7	1000	850	1030
Clark Ck (A)		9	51	0.50	1.77	9	12	15	1	300	437	365
Clark Ck	5.7	12	69	1.5	1.50	13	11	25	9	1125	525	22750
Clark Ck (B)		5	62	0.50	1.93	9	16	21	3	675	525	2250
Ponca Ck (A)		< 1	43	0.55	1.56	6	13	11	1	550	375	230
Ponca Ck	7.0	58	1140	4.25	2.14	11	8	19	5	450	335	9995
Ponca Ck at Ponca	7.0	9	72	1.15	2.50	18	19	33	7	1425	750	15250
Adds Ck	7.0	20	368	57.50	3.52	21	17	38	30	1500	462	18750
Leatherwood Ck	7.0	5	90	1.50	2.29	17	18	24	7	1325	1035	19750
Leatherwood Ck (B)		4	54	0.65	1.46	8	13	14	1	425	425	1350
3 Name Ck (A)		5	87	1.00	2.03	11	18	19	2	775	725	9250
3 Name Ck	9.7	18	90	2.00	1.47	17	28	29	7	1025	1035	18495
3 Name Ck (B)		8	122	0.65	2.07	9	18	20	2	1150	537	370

by non-unique sediments of the river takes place in an extremely short distance, especially as shown by Beech, Moore and Ponca Creeks (Table 30 and e.g., Fig. 25).

The Fe values for the bottom sediments in the upper part of the river and also in the tributaries in this area exhibit a decrease downstream (Fig. 26) similar to that for the entire river. Cu, Mn, Cr, Co, Mg and Ni have trends similar to that for Fe (Table 30). An optical examination of the sediments indicated that shale fragments make up about 25% of the samples from the upper portion of the Buffalo River and the amount of shale fragments gradually diminishes to about 10% near Ponca. The Pb-Fe trend in Figure 27 indicates sorption of Pb by the ferric oxide coatings, and the anomolous values indicate the presence of lead-rich clasts. Similar trends were found for Mn, Co, Cr, Cu, Ni and Zn.

The values for Zn show little variance from the background level of about 65 ppm (Table 30) except for Beech Creek, which also has anomalously high Pb concentrations, and for Adds and Ponca Creeks, which have reported Zn mineralization. As in the case of lead, zinc values for Ponca Creek near its mouth are higher than those at the two sites upstream. Again this may indicate mineralization or contamination from tailings. Cadmium concentration is erratic.

The Cd/Zn ratio for the bottom sediments from the upper part of the river was found to be relatively constant (8-10 ppm Cd to 1000 ppm Zn) and similar to that for ore from the area near Rush, Arkansas. The Cd/Zn ratio for Buffalo River sediments from the Boxley-Ponca area falls within the same range. However, the tributaries show a much greater range which

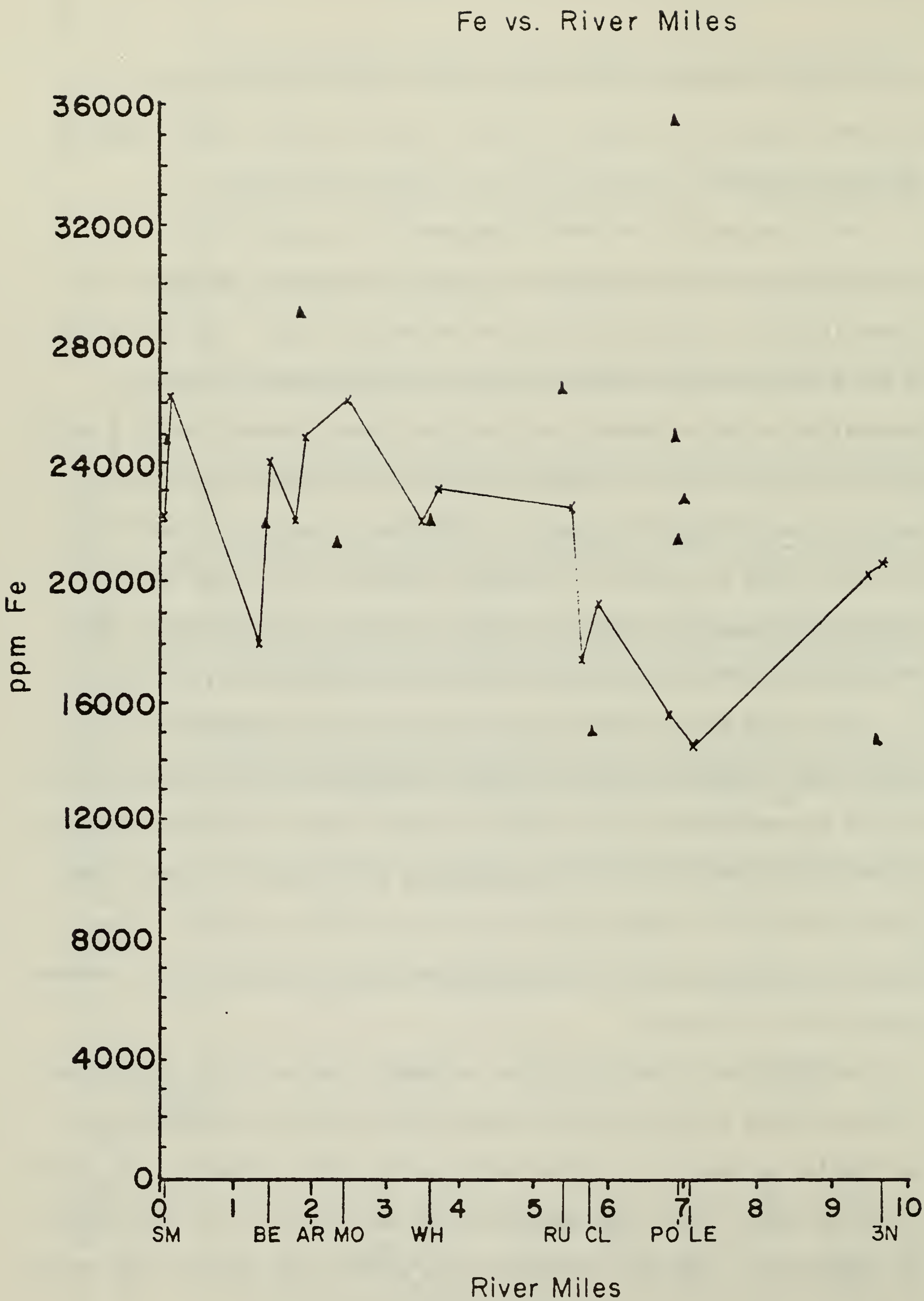


Figure 26. Fe vs river miles from Smith Creek (SM) in the Ponca-Boxley District.

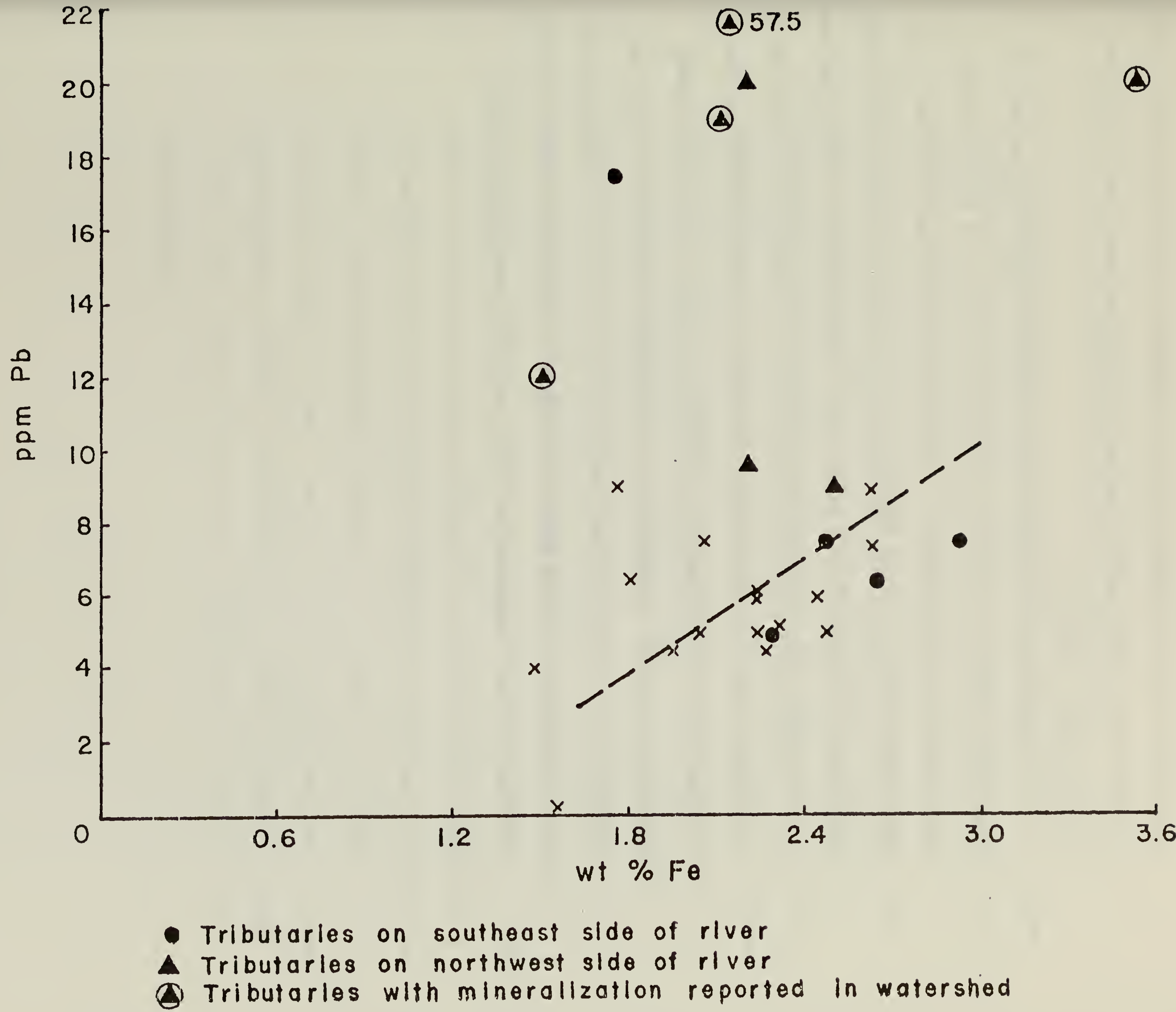


Figure 27. Pb vs. Fe for bottom sediments collected in the Ponca-Boxley District.

may simply indicate homogenization of sediments with various Cd/Zn ratios by the river. The Pb and Zn contents of the sediments are independent of one another (Table 30).

Ca concentration increases downstream, reflecting the presence of limestone (Table 30). There is no dolomite in the area and the Mg data agree with this information. Significant correlations of certain elements with Ca+Mg have been reported for the lower portion of the Buffalo River (Fig. 22); however, none were found in this portion of the study area.

In summary, in the Ponca-Boxley District, lead mineralization has a significant effect on the Pb concentration in bottom sediments of the tributaries, but concentrations are quickly diluted in the main stream. Mineralization also increases zinc and cadmium concentration. The concentration of Ca is controlled largely by the presence of limestone, and the concentrations of the other elements are controlled primarily by the presence of shale fragments and sorption by Fe oxide coating clasts.

SUSPENDED SEDIMENTS

Sample Collection and Preparation

Suspended sediments were collected from the eight stations shown in Figure 17 and also from Ponca, Rush and Clabber Creeks on 5/21-22/74, 6/17/74, 8/19-21/74, 12/20-21/74, and 3/26/75. One half to one liter of water was filtered in the field through a 0.45 μm Millipore filter using a hand operated vacuum pump. The filters were prewashed for 30 minutes in 1:1 HCl and rinsed in distilled, deionized water in the laboratory prior to the collection trip. After filtration the filters were returned to the laboratory and placed in a 25 ml Erlenmeyer flask with 2 ml of concentrated HCl overnight. The extractant was then diluted to 25 ml and the filter rinsed several times in distilled, deionized water. The sample was then ready for analysis by atomic absorption spectrometry. The atomic absorption technique used was the same as that for the bottom sediments. Analyses were attempted on a per weight basis of the suspended sediments but this was not feasible because of the small amount of material that could be collected in a reasonable length of time. Therefore, the suspended sediment analyses are expressed in terms of concentration per liter of water filtered. Hg, As, and Cu were not determined because of their extremely low concentrations.

Element Variation

The concentration of elements in the suspended sediments is quite low (Table A2 and summarized in Table 31). The concentration of elements in the water generally exceeds that in the suspended sediments, except in the case of iron (Tables 31 and 32). Generally, there is about 10 times as much suspended iron per liter of water as dissolved iron (Tables 31 and 32). Na and K values are variable from station to station; however, there is no systematic variation. All of the other element concentrations are essentially constant from station to station. Station 1 (Boxley) has the largest K and Zn concentrations, probably because of the greater amount of clay particles derived from the shale in the area (Table 31).

Suspended sediments from the river contain more Na, K, Fe and Mn than those from selected tributaries (Table 31). The high Na and K values can be attributed to greater amounts of clay particles because the river is a collection point for fine particles compared to the tributaries (Steele and Wagner (12)). Also, there is no major source of clay in these creeks' drainage basins. The higher Fe and Mn could be directly due to the presence of clay particles but could also be caused by oxide coatings of the elements on fine grains. Again, the creeks have no major source of these elements compared to the river because there is no shale in their drainage basins. Although there are elemental variations with the season, there is no pattern of change (Table 31).

Table 31 Suspended material (<0.45μm) in Buffalo River and four tributaries*.

Sta- tion	River Miles	Na	K	Ca	Mg	Fe	Co	Cr	Ni	Zn	Cd	Pb	Mn	Li***	Sr***	pH	T°C	D.O. ppm
		Average values (μg of element suspended per liter of water = ppb) per station for five sampling periods, May 1974 to March 1975																
1	130	47	23	18	7	144	<1	<1	2	14	0.4	<3	4	0.1	0.7	7.3	16.8	9.9
2	101	36	1	18	6	136	<1	<1	<1	2	<0.4	12	9	<.1	0.6	7.5	16.3	9.4
3	104	3	4	29	5	112	<1	<1	<1	2	<0.4	2	7	<.1	0.8	7.4	15.4	9.5
4	94.1	8	2	23	6	128	<1	<1	1.6	1	<0.4	<3	9	0.10	<0.7	7.4	16.7	9.7
5	55.2	42	3	31	7	157	<1	<1	0.6	1	<0.4	3	6	<.1	0.5	7.4	17.7	10.0
6	33.5	6	8	37	6	112	<1	<1	<1	1	<0.4	<3	6	0.05	<0.7	7.6	17.6	9.9
7	31.4	9	3	40	7	121	<1	<1	4	1	0.1	<3	7	0.10	<0.7	7.6	17.3	9.6
8	23.3	32	3	36	8	100	<1	<1	2	3	<0.4	<3	6	0.10	<0.7	7.5	17.2	9.6
Clab- ber Cr.	23.5	19	8	25	14	14	<1	<1	<1	1	0.1	2	1	0.02	<0.7	-	-	-
Rush Cr.	23.7	24	1	20	6	25	<1	<1	<1	2	0.4	<0.6	2	0.04	<0.7	-	-	-
Ponca Cr.	120	11	1	25	3	95	<1	<1	1	3	0.1	1	4	0.13	<0.7	-	-	-
River Average**		23	6	29	6	126	<1	<1	2	3	0.25	6	7	0.09	0.7	7.5	16.9	9.7
Creek Average**		18	3	23	8	45	<1	<1	<1	2	0.20	1.5	2	0.06	<0.7	-	-	-
Collection Date		Average values (μg of element suspended per liter of water = ppb) per collection date for eight river stations																Flow[b] CFS
5-22-74		-	-	31	6	110	<1	0.4	3	8	0.4	19	5	-	-	7.4	21	1003
6-17-74		34	4	21	10	227	<1	0.5	2	3	0.2	<1	8	-	-	7.6	21	1280
8-21-74		11	4	53	5	48	-	-	-	3	-	-	15	0.1	0.7	7.4[a]	27[a]	75
12-21-74		<10	<1	21	4	76	<0.3	<0.5	0.8	<1	<.15	<3	4	<0.1	<0.4	7.1	6	541
3-20-75		6	4	24	7	151	-	-	-	2	-	-	5	0.1	0.3	7.7	12	2060

(continued)

Table 31 (cont'd).

* Tributaries are station 3 (Little Buffalo River), Clabber Creek, Rush Creek, and Ponca Creek.

** River average includes Little Buffalo River, station 3.
Creek averages are for Clabber, Rush, and Ponca Creeks only.

*** Only last 3 samplings were analyzed.

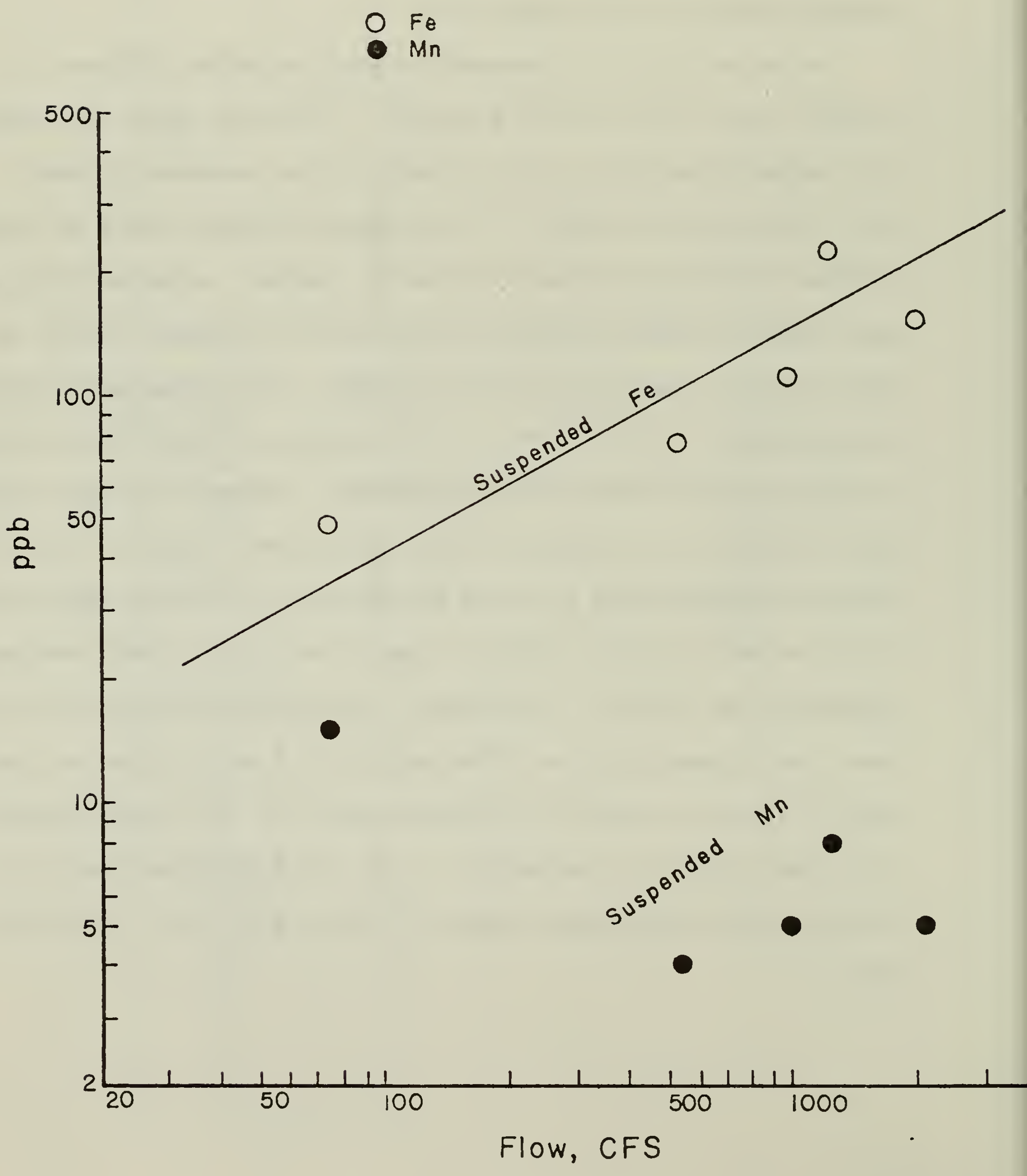
[a] For 8-14-74.

[b] Cubic feet per second of water flow measured near station 5, approximate midpoint of river.

There appears to be a correlation of Fe content with flow of the river (Fig. 28). Although Mn generally follows Fe, Mn concentration and flow relationships do not correlate nearly as well as Fe and flow. This correlation is simply the result of Stokes Law, i.e., there is more suspended material with greater flow.

The Mn/Fe ratios for suspended relative to bottom sediments are plotted versus river miles in Figure 29. This graph shows that except for station 1 the Mn/Fe ratio is greater in the suspended sediments than in the bottom sediments. The suspended sediments would be expected to have initial oxide films of Fe and Mn, whereas bottom sediments, because they are heavier and have settled out of the water, would be expected to have older and more oxide coating. Late formed oxide coatings are apparently enriched in Mn with time because of some factor such as an autocatalytic effect on Mn precipitation. Station 1 differs from the other stations in that there is shale in the area. Station 1 has a greater absolute amount of Fe and Mn compared to the other stations (Table 31). It may be that the large amounts of these ions cause a different sorption pattern at the locality. For example, the high concentration of Fe may cause less autocatalyzation of Mn precipitation on the suspended sediments. Also, the presence of shale fragments in the bottom sediments could add to the acid leached Fe. It is also interesting that pH increases slightly downstream (Table 31) and may also play a significant role.

Figure 28. Suspended sediment Fe and Mn values vs flow of river. Fe and Mn values are average values for five collection dates. Flow determined at approximate midpoint along river (station 5).



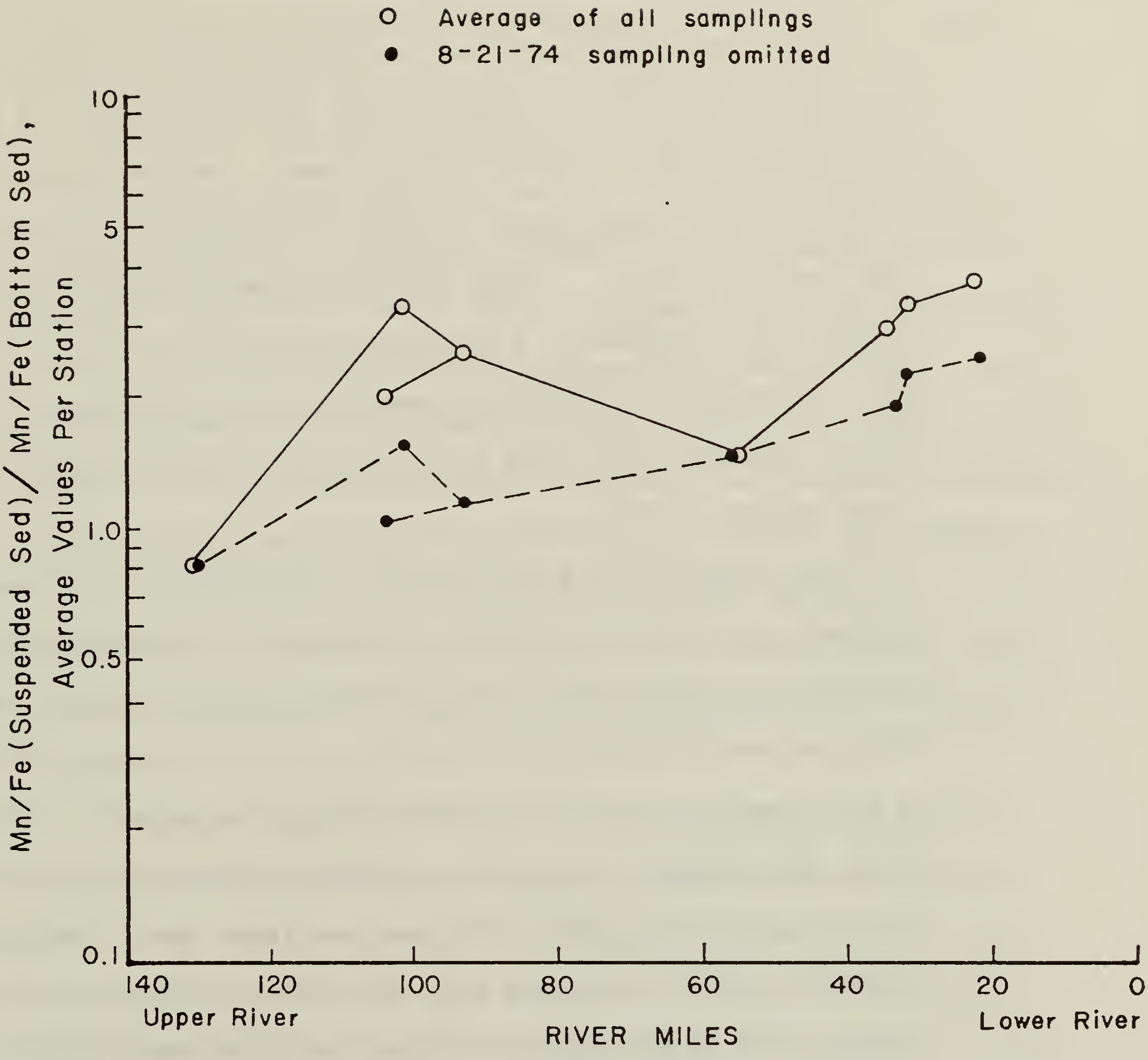


Figure 29. Average Mn/Fe ratios of suspended sediments relative to those of bottom sediments for the eight stations.

DISSOLVED MATERIAL

Sample Collection and Preparation

Water samples were collected on 3/12/74, 5/21-22/74, 6/17/74, 8/19-21/74, 12/20-21/74 and 3/26/75 from the eight stations in Figure 1 and also from Ponca, Rush and Clabber Creeks. Two hundred and fifty to 500 ml of water was passed through a 0.45 µm filter and collected in a polyethylene bottle; eight drops of concentrated per 100 ml of filtered water were added. A hand vacuum pump was used in the filtration. The Millipore filters were prewashed in the laboratory in 1:1 HCl for 30 minutes, and rinsed with distilled, deionized water prior to the collection trip.

Many elements in the water require concentration before analysis by atomic absorption spectrometry. A procedure of chelation with diethydithiocarbamate (DDC) and extraction by methyl isobutyl ketone (MIBK) was used to concentrate Cd, Co, Cu, Cr, Ni, Mn, Fe, Zn, and Pb. Zn were sometimes present in concentrations large enough to allow direct determination in the water. Agreement between direct water analysis and organic concentration was not always good. The organic extraction value is preferred over the direct water determination because there is less flame interference with the organic extract.

The organic concentration procedure is modified from that used by Nix and Goodwin (15). One hundred and fifty ml of water is placed in a 250 ml Erlenmeyer flask. Three ml of phthalate buffer is added and the pH adjusted to 3.6 ± 0.1 with 1 M HCl and 1 M NaOH reagents. Ten drops of an indicator prepared from a 1:1 mix of

bromeresol green (Sargent S-41665-KE) and benzo yellow (Sargent S-41665-KC) are added. Next 10 ml of DDC is added. The contents of the Erlenmeyer flask are transferred to a 500 ml Teflon stopcock sepratory funnel. Twenty-two ml of MIBK is added to the funnel and the contents are shaken briskly for 30 seconds. The funnel contents are allowed to stand and separate (this normally requires about one hour). The organic phase is then withdrawn for analysis. Transfer of material can be avoided by adding all reagents to a 200 ml volumetric flask. The organic phase will separate and rise into the neck of the flask and the aspirator for the atomic absorption spectrometer can be placed directly into the flask. This method was used for some of the latter samples. Standards were prepared from Eastman metal organic compounds: cyclohexanebutyric acid cadmium salt, manganous cyclohexanebutyrate, cyclohexanebutyric acid cobalt salt, nickel cyclohexanebutyrate, chromium (III) benzoylacetonate, ferric benzoylacetonate, lead cyclohexanebutyrate, copper cyclohexanebutyrate, zinc cyclohexanebutyrate.

The other elements in Tables 32 and A3 were analyzed by standard atomic absorption spectrometry procedures described for bottom sediments. The detection limits for the organic extracted elements in ppb are Fe (0.5), Co (0.3), Cr (0.4), Ni (0.3), Cu (0.06), Zn (0.07), Cd (0.02), Mn (0.07), and Pb (0.7). Hg and As were not determined because of their extremely low concentrations.

Element Variation

Water concentrations of major elements along the Buffalo River (Fig. 30, Tables 32 and A3) generally follow the geology as in the case

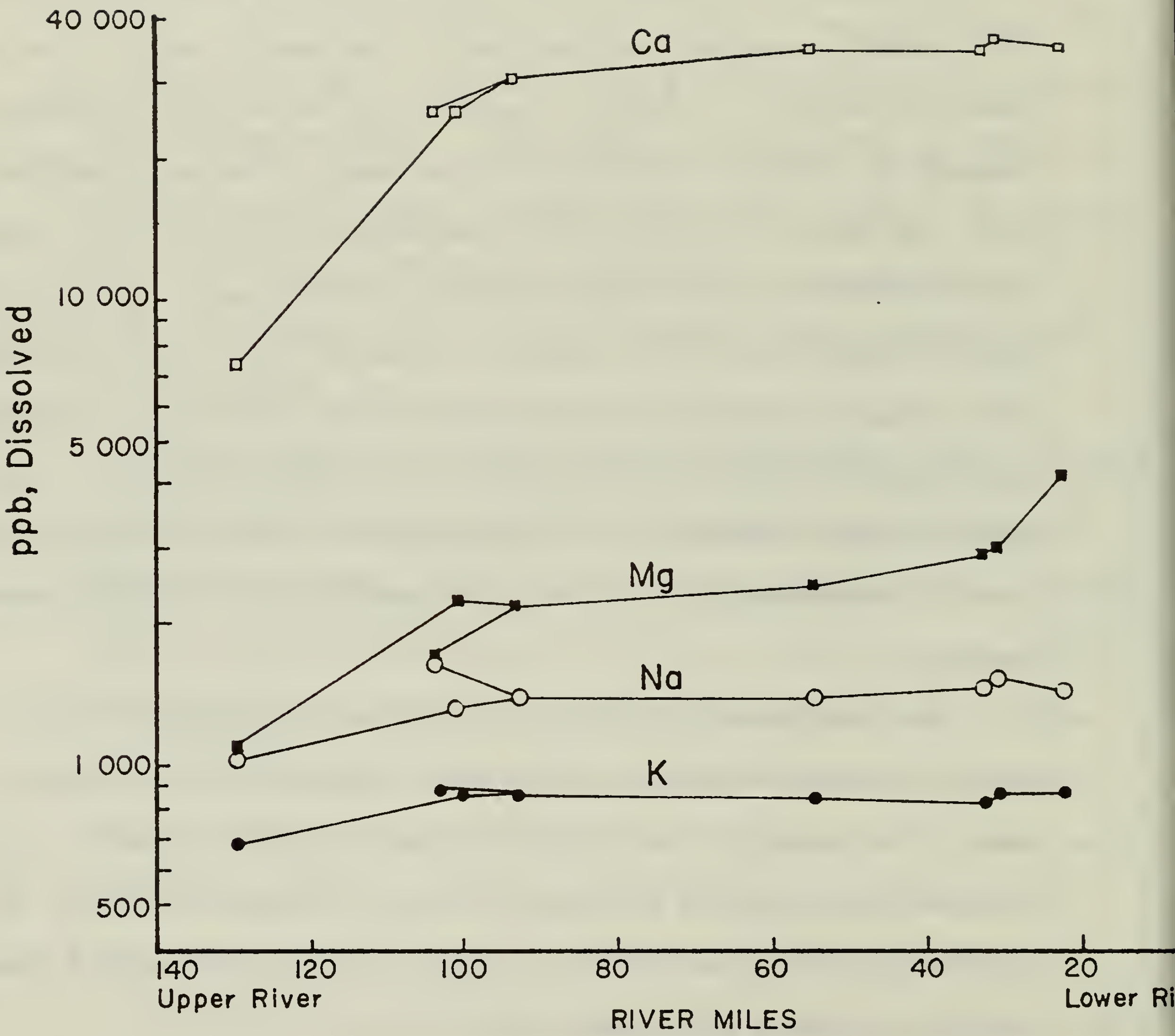


Figure 30 . Dissolved river load (major elements) vs river miles.

Average values for each station plotted.

Table 32. Dissolved material in Buffalo River and four tributaries*.

Average values (ppb) for six sampling periods, March 1974 to March 1975.

Station	River Miles	Na	K	Ca	Mg	Fe	Co	Cr	Ni	Cu	Zn	Cd	Pb	Mn	Li***	Sr***	pH	T°C	D.O. ppm
1	130	965	681	7440	995	21	6.6	<2	4.7	3.9	80	1.2	5.1	4.3	2.0	8.5	7.3	16.8	9.9
2	101	1352	846	27033	2288	19	2.8	3	2.9	2.2	30	0.8	5.5	9.4	2.0	33	7.5	16.3	9.4
3	104	1679	864	27383	1799	12	3.7	<2	3.2	2.4	58	1.0	6.3	8.4	2.0	42	7.4	15.4	9.5
4	99.1	1401	843	30600	2231	11	3.6	<2	4.1	2.8	23	0.9	6.3	7.6	2.0	34	7.4	16.7	9.7
5	55.2	1366	876	35567	2470	9	3.1	2	3.1	4.3	62	0.6	4.0	8.5	1.5	38	7.4	17.7	10.0
6	33.5	1438	837	35817	2893	18	3.9	1.5	3.1	4.3	18	1.0	6.0	5.7	1.5	42	7.6	17.6	9.9
7	31.4	1497	848	36133	2925	10	4.2	2.5	3.6	2.7	15	1.4	4.5	7.3	1.5	43	7.6	17.3	9.6
8	23.3	1465	856	36900	4182	8	4.1	1.0	3.4	2.0	64	1.3	4.8	7.9	1.0	38	7.5	17.2	9.6
Clabber Cr.	23.5	1132	861	51625	26575	6	4.4	<2	4.0	1.3	14	1.2	2.6	7.7	2.0	33	-	-	-
Rush Cr.	23.7	1420	831	52125	8900	6	5.3	<2	4.1	1.6	41	1.4	6.8	4.1	2.0	32	-	-	-
Ponca Cr.	120	1487	985	41340	3084	7	3.7	4	4.6	2.2	32	0.9	4.7	9.9	2.0	33	-	-	-
River Average**	-	1395	825	29609	2473	13	4.0	2	3.5	3.1	27	1.0	5.3	7.4	1.7	35	7.5	16.9	9.7
Creek Average**	-	1346	892	48363	12853	6	4.5	4	4.2	1.7	29	1.1	4.7	7.2	2.0	33	-	-	-

Average values (ppb) per collection date for eight stations

Collection Date	Na	K	Ca	Mg	Fe	Co	Cr	Ni	Cu	Zn	Cd	Pb	Mn	Li***	Sr***	pH	T°C	D.O. ppm	Flow[b] CFS
3-12-74	1180	833	20600	1611	31	-	-	-	4.9	7	1.4	4.6	7.0	-	-	7.5	14	9.9	5170
5-22-74	1228	860	29737	2434	11	2	<2	4.0	<4.0	29	1.2	7.8	7.5	-	-	7.4	21	8.4	1003
6-17-74	1231	865	40587	2779	6	2	<2	6.2	1.4	51	<1.0	5.0	7.2	-	-	7.6	21	8.8	1280
8-21-74	2230	1106	45333	3871	7	4.3	1.8	2.7	<1.0	16	<1.0	3.6	8.5	1.4	52	7.4[a]	27[a]	8.0	75
12-21-74	1250	644	26262	2248	8	3.1	<2	2.6	1.7	97	0.7	0.7	7.0	<2.0	26	7.1	6	12.5	541
3-26-75	1412	695	25537	2254	17	4.2	<2	1.8	1.5	20	0.6	5.9	7.6	1.9	31	7.7	12	10.6	2060

(continued)

Table 32 (cont'd).

* Tributaries are station 3 (Little Buffalo River), Clabber Creek, Rush Creek, and Ponca Creek.

** River average includes Little Buffalo River, station 3.
Creek averages are for Clabber, Rush and Ponca Creeks only.

*** Only samples from last three collections analyzed.

[a] For 8/14/74.

[b] Cubic feet per second of water flow measured near station 5, approximate midpoint of river.

of the bottom sediments. Nix (16) has found similar relationships with close sampling of water along the river. Calcium and Mg increase in concentration downstream where carbonate rocks (limestone and/or dolomite)are encountered. Although K and Na exhibit very little variation along the river, they are clearly present in lower concentrations upstream. Shale,which is relatively rich in these two elements compared to other rocks in the area, is present upstream. However, clay tends to scavenge Na and K from the water, sorbing them on its surface and between layers. Because of the presence of shale and clay particles in the bottom sediments upstream and possibly because of the presence of feldspar (a source of Na and K) downstream in sandstone, the trend for Na and K is a slight increase in concentration downstream.

Some of the minor elements also follow trends similar to that for the major elements (Figs. 31 and 32). Strontium substitutes for Ca in minerals, and is present in limestone. Strontium follows a trend similar to Ca, i.e., increases in concentration downstream. A trend of decreasing Fe downstream is observed; however, there is an increase in the zinc mining district. This is probably because a major source of iron is the shale in the upper portion of the drainage basin; the dissolved iron is diluted and precipitated downstream. Cu and Cd follow a trend similar to Fe. Mn concentrations are relatively constant (4-9 ppb). The low value for dissolved Mn is at station 1 in an area with a large amount of Mn present in the bottom sediments (Table 27). The effectiveness of sorption processes here may be greater because of the large Fe and Mn concentrations and thus may remove a relatively greater amount of Mn from solution here than at other stations. Li concentration decreases downstream. Pb values are extremely constant, whereas Zn concentration is

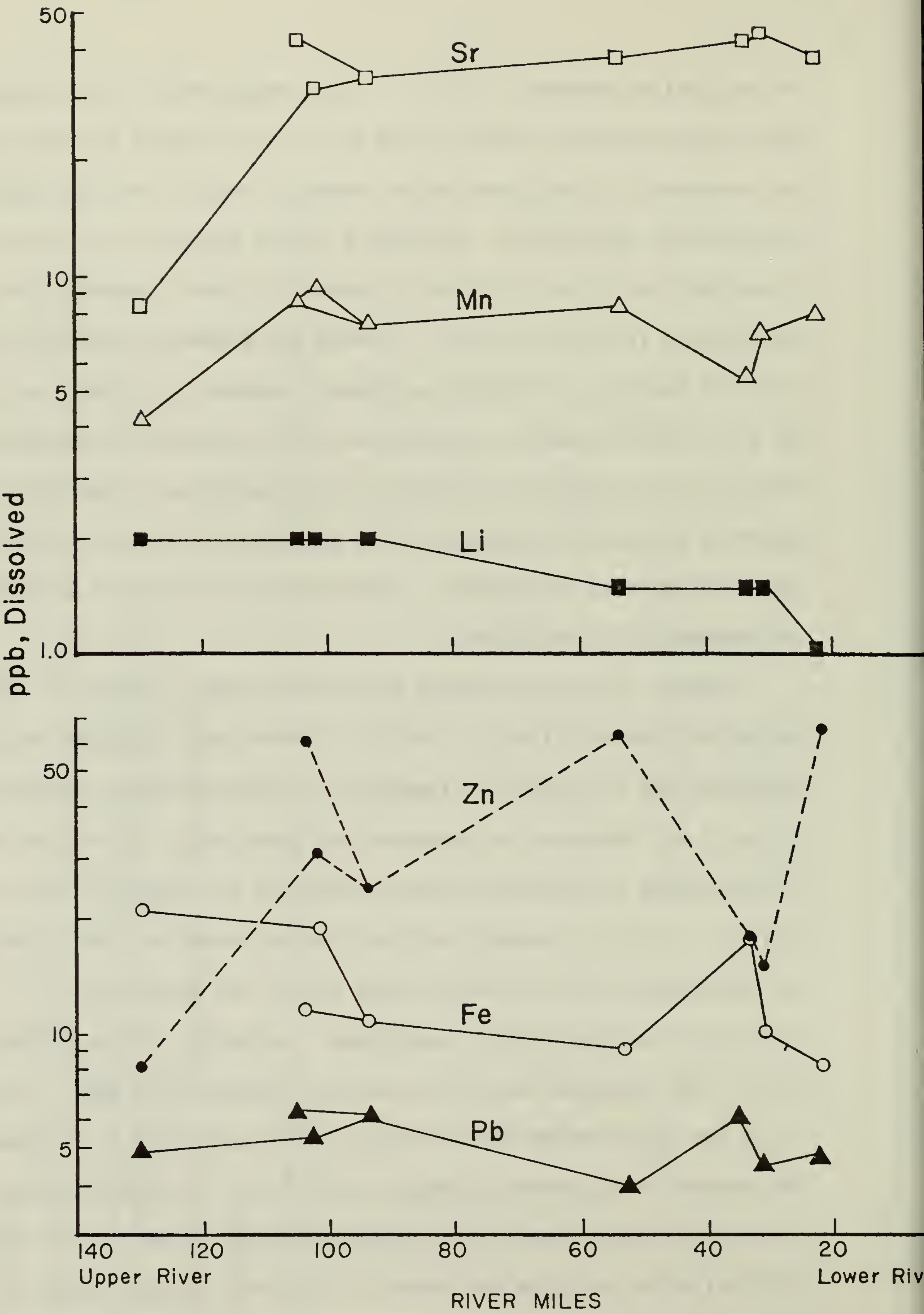


Figure 31 . Dissolved river load (minor elements) vs river miles.

Average values for each station plotted.

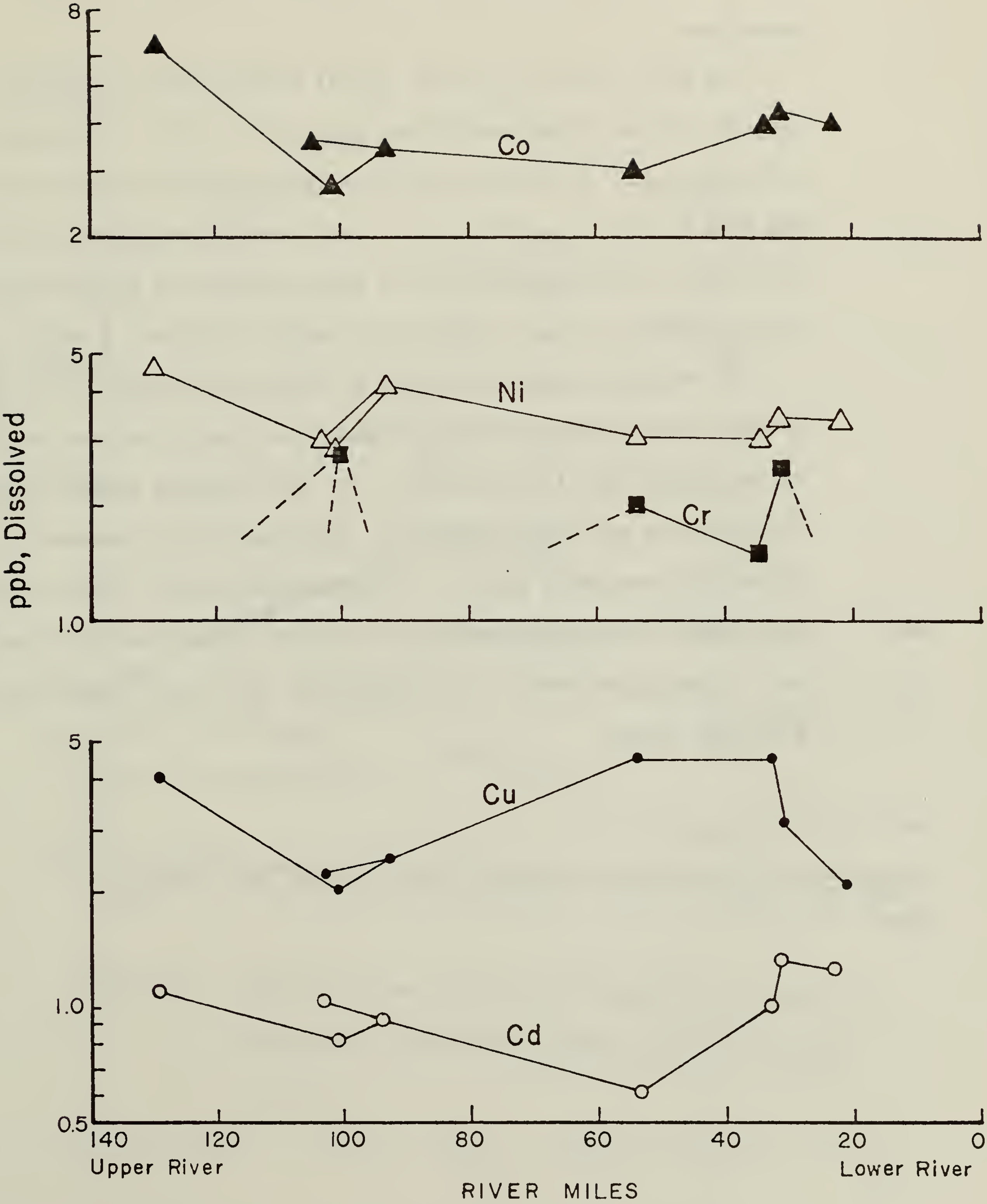


Figure 32 . Dissolved river load (minor elements) vs river miles.

Average values for each station plotted.

quite variable. Co and Ni generally decrease in concentration downstream.

The major ions (Ca, Mg, Na, and K) have seasonal fluctuations with greatest concentration during late summer (Fig. 33). This pattern correlates with the flow pattern, with the greatest concentration during low flow for the river (Fig. 34). This correlation can be explained as the result of the concentration of these elements by evapotranspiration during periods of least rainfall (or lack of dilution by rain).

Of the trace metals, Pb shows a pattern with season (Fig. 35). The pattern closely matches that for temperature and is an inverse for dissolved oxygen variation with time. As the dissolved oxygen content increases the Pb content decreases. Mn solubility is apparently not affected by the above factors - the Mn concentration of the river is very stable throughout the year. The other element variations with time are irregular and there is no correlation with flow, temperature or dissolved oxygen.

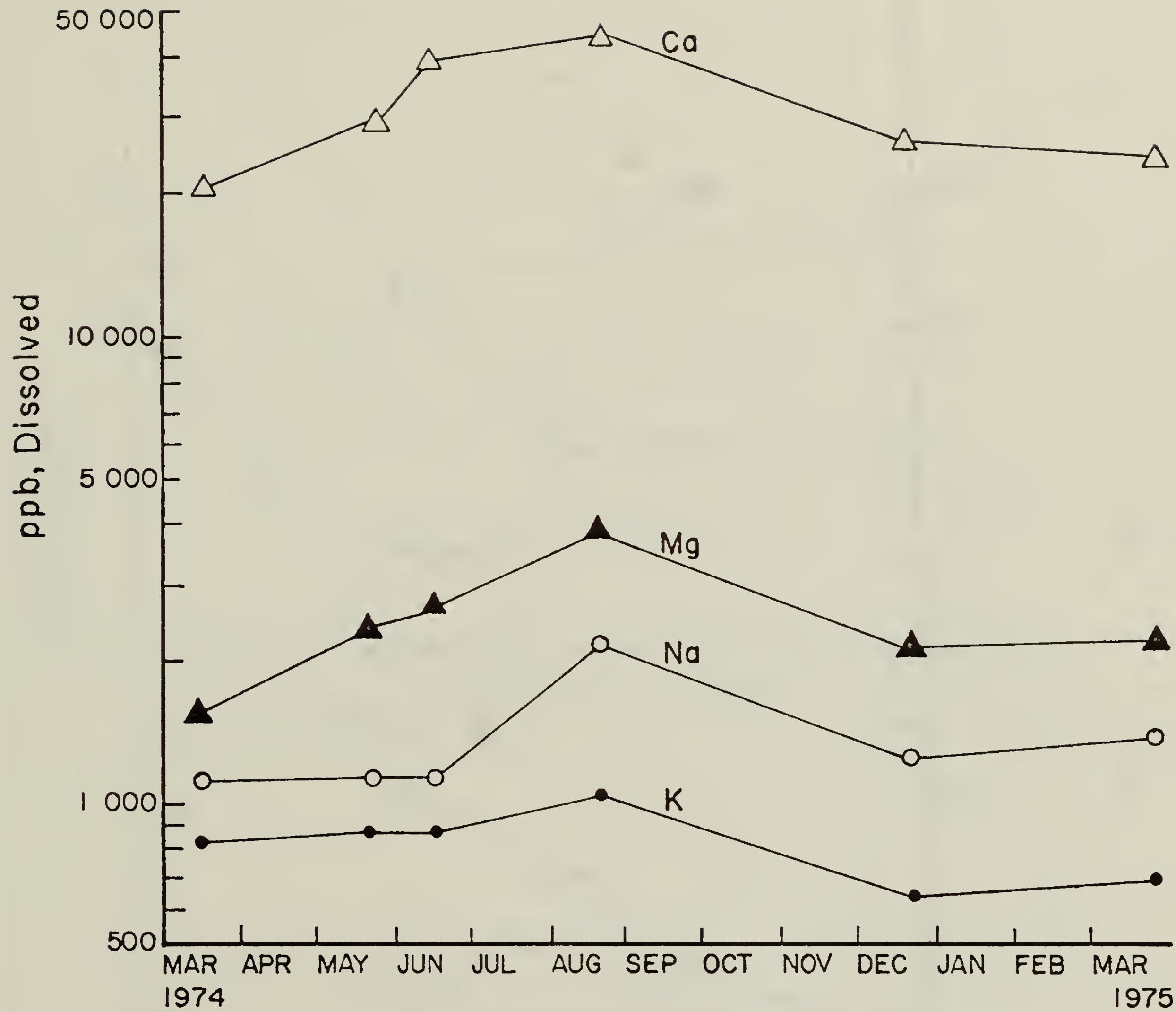


Figure 33. Dissolved river load (major elements) vs month of collection. Points are average values for eight stations.

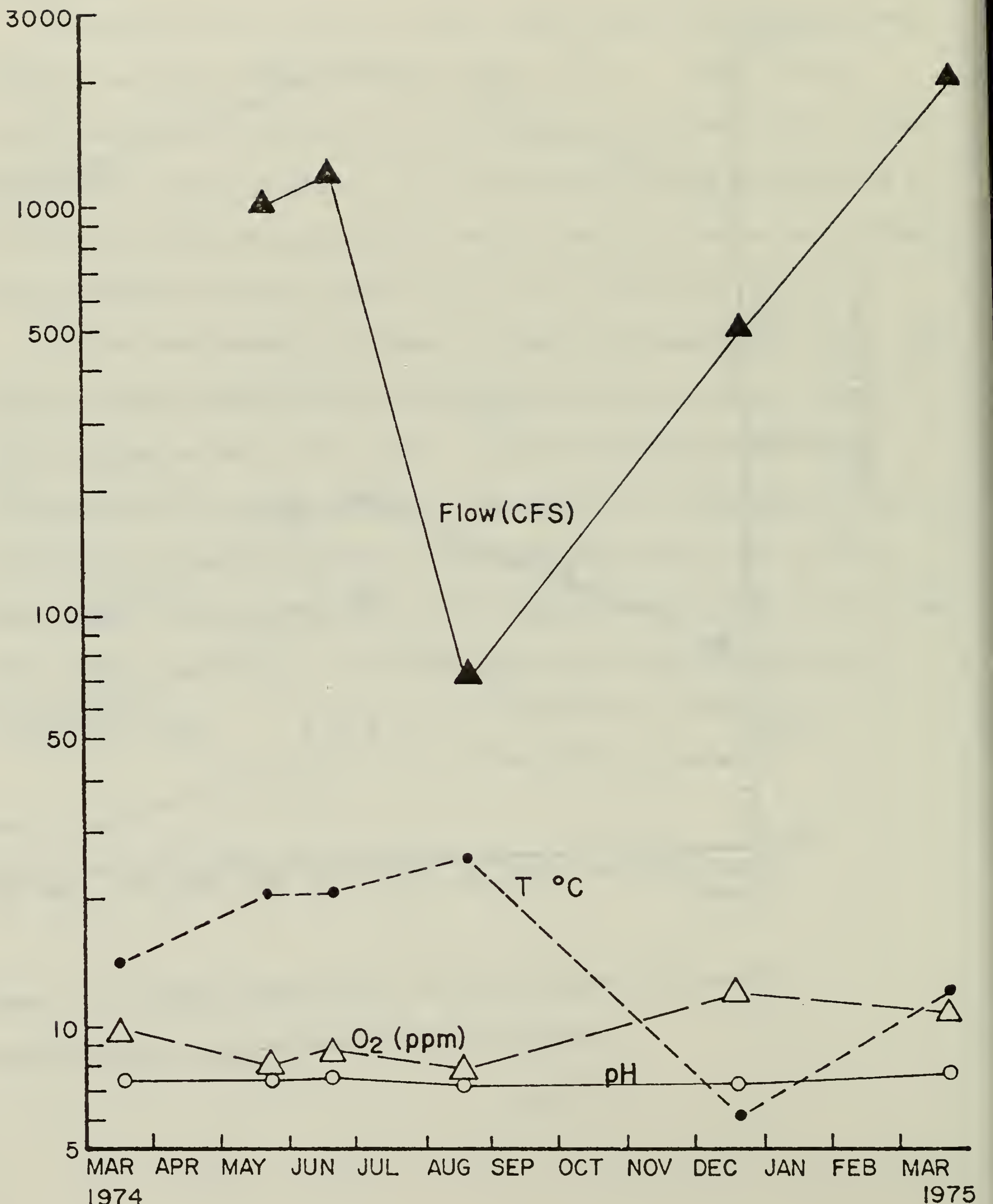


Figure 34 . River water properties. Each point is an average valu

for the eight stations except flow, which is for a

station near midpoint along the river (station

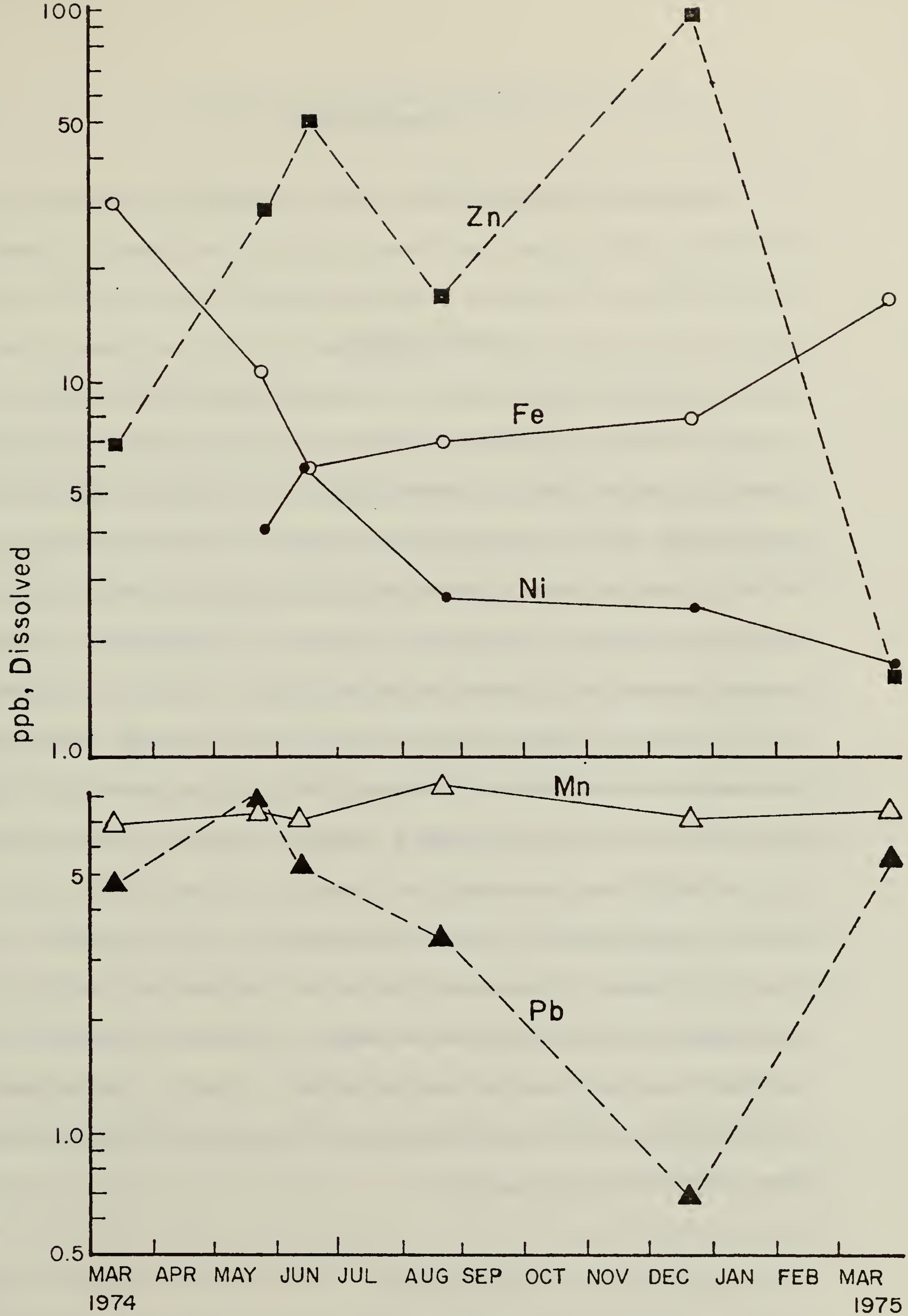


Figure 35. Dissolved river load (minor elements) vs month of collection. Points are average values for eight stations.

CONCLUSIONS[1]

Elements are present in iron oxide coatings of the bottom sediments and many are also present as mineral clasts. The trends of element concentrations in the water and bottom sediment along the river correspond with rock type changes and abundance of the rock types in the river valley and mineralization. Unique sediments from tributaries are quickly diluted by mainstream sediments. However, perhaps attention should be given to ensuring stabilization of ore and tailings piles in the old lead and zinc mining areas in order to minimize pollution of the Buffalo River sediments. Water composition is also affected by flow which has a seasonal fluctuation. During low flow (August) the major element content of the water increases because of lack of dilution by rain. The trace element concentrations do not correlate with season. Suspended sediment element concentrations (measured during non-storm periods) are very low. Suspended sediment element concentration levels are generally less than those for the water, except in the case of Fe which is approximately 10 times more abundant in the suspended sediments than in the water. Because of the narrow concentration range and very low element concentrations in the water, relationships between the sediments and water are not easily defined. However, the sediments from the Buffalo River can possibly be treated as a rough indicator of long term river water quality.

[1] Note that the concentration of the elements in the suspended load of the river is expressed per volume of water rather than per unit weight of sediment. A study of the suspended load of the river; however, has not been made.

SPATIAL AND TEMPORAL DISTRIBUTION OF ALGAE AND ASSOCIATED PARAMETERS

Laura L. Rippey and Richard L. Meyer

INTRODUCTION

Algae inhabiting flowing waters such as the Buffalo River face a greater challenge than those living in standing waters. To meet this challenge there is a certain amount of adaption and differentiation between those algae inhabiting pools and riffles. True plankton is not frequently encountered in mountain streams similar to the Buffalo River. Potamoplankton occurs in large rivers or streams with input from lakes or ponds. Occasionally plankton is found in still pools in the summer when the water level in the river is low. Most of the organisms found in the plankton are derived from the periphyton community (Meyer (17)). Most of the algae found, though, exist as periphyton and of this periphyton the majority of the forms are epilithic.

Location in a protective nook by means of some mode of attachment gives algae growing in currents the advantage of survival ability. The leeward edge of a submerged stone provides a favorable biotope with minimal chance of being washed away. It is also important in lotic situations to be able to withstand mechanical stress, the pulling and twisting caused by flowing water as well as abrasion by silt. It was noted by Blum (18) that algae which exist in rapid waters have four principal types of adaptions. Batrachospermum and Stigeoclonum are examples of two which display branched filaments with a holdfast and a

gelatinous coat. Filaments of Spirogyra are long flexible cylinders which align themselves with the current. Another adaptation is the spherical or cushion-like colonies containing many filaments of algae like Cladophora or Nostoc. Such colonies have smooth surfaces so they offer little resistance to the current. A fourth modification is the simplified plate-like forms like Phormidium which are tightly fixed to the contours of the rock. So there are modifications which lend advantage to algae of flowing waters and further, some of those algae such as Batrachospermum, Cladophora, Spirogyra and Oedogonium seem to be restricted to lotic situations (Dillard, (19)).

The physical aspects of flowing waters may be as important as the mechanical ones just discussed. Moving water is not absolutely, but rather physiologically, richer in oxygen and nutrients (Ruttner, (20)). This physiological richness is due to the action of flowing water moving materials over the cell surface so that the nutrient deficient zone does not form in the microhabitat around an algal cell as it would in lentic habitats. This movement causes a steep diffusion gradient to be maintained so that the exchange between the organism and its environment is increased.

MATERIALS AND METHODS

Samples for algae and chemical data were taken at all of the eight standard stations illustrated in Figure 1.
In addition to these eight stations collections were also made at the low water bridge at Ponca. This station was chosen because of its proximity to Boxley which is dry during the summer months.

Plankton samples were collected with a 15 cm. diameter, 25 mesh hand held net. More abundant than plankton were the attached forms. These were collected for quantitative samples by means of scrubbing rocks with a nylon bristle brush and washing the loosened material into a beaker. Samples to be preserved were put into vials with M_3 fixative (Meyer,(21)). Live samples were also taken.

Both preserved and live algae samples were examined by an Olympus PM-10-M phase-contrast microscope as wet mounts. Several slides were made from each sample vial in order to have a complete list of genera present. Two permanent slides of diatoms were made at each station . These were prepared by means of treating the frustules with hot potassium dichromate-sulfuric acid cleaning solution to remove the protoplast, washing the diatoms in distilled water and permanently mounting them in Hyrax, refractive index 1.65. This process facilitates diatom identification by exposing the fine wall markings which are the taxonomic characteristics.

Water samples used for the chemical analysis were collected in plastic bottles. Turbidity readings were made on raw water samples by a Hach Analytical Nephelometer Model 2100A. Ammonia was also measured on raw water samples by means of direct or standard addition methods with the Orion specific ion probe. These determinations were usually made on the same day the water was collected, then it was filtered through a Millipore filter apparatus and refrigerated overnight. Nitrate-nitrogen was determined by the ultraviolet method (Standard Methods,(22)). Orthophosphate was measured by the ammonium molybdate procedure also found in Standard Methods (22).

Silicas were diluted 1:4 and measured by the heteropoly blue method described in Standard Methods (22).

RESULTS AND DISCUSSION

The emphasis of this study is on the seasonal aspects of the algae and chemical parameters of the Buffalo River. Since samples included in this report span from August 1974 to April 1975, there are samples representing each season (Table33). It is obvious that photosynthesis and growth of algae are dependent on the duration, quantity and quality of light. There are correlations between the appearance of foliage on the trees and the disappearance of some algae,while others are shade tolerant. So the algal populations of the Buffalo change during the course of a year. Not all algae which occur concurrently can be called assemblages since they may be haphazard combinations of species which have no definite pattern of organization from one site to another. In other cases there might be a lack of a definite community structure that recurs seasonally from one year to the next.

This does not mean that there is no community structure in the Buffalo River. It does mean that one must be cautious about assigning names to clusters of algal species. During late spring and summer a community composed of several species of Spirogyra associated with Oedogonium was a dominant feature along the river. Oedogonium was present in almost every sampling period while Spirogyra, which appeared in greater quantity in July and August, was found infrequently at other times of the year. Summer also brings low water resulting in deep still pools between the riffles.

Occurrence of flagellates like Branchiomonas, Lobomonas, Chlamydomonas and Gonium among others is restricted to these still pools. The station at Hasty was in August reduced to a deep still pool with no visible flow. Euglena, Strombomonas and Trachlomonas as well as Chlamydomonas were recorded under these conditions. Other typically planktonic genera found in still pools of the Buffalo are Pediastrum, Staurastrum, Coelastrum, Ceratium, Pandorina, Stephanodiscus and Cyclotella. In the warmer times of the year another unique niche is available in the river, the vascular phanerogams. Beds of water willow, Justicia americana, provide a substrate for the attachment of epiphytic algae. Some of these epiphytes include Chamaesiphon and Cocconeis.

No great algal blooms developed in the autumn as typically occurs in lakes. As the water temperature fell and the water level rose, increased flow kept the algal populations low. Visually this was evidenced as extensive expanses of clean gravel. In December the stones in the river were covered with golden brown gelatinous coats of diatoms of various genera. This epilithic population continued to be prominent throughout the winter months. In these diatomaceous gels which covered the rocks, desmids were also found. At all stations with the exception of Rush, desmids including Cosmarium, Closterium, Staurastrum and Stauradesmus were reported. In the later part of the winter these epilithic populations were scoured off of the rocks by the action of the silt-laden waters. Again in the spring another extensive epilithic population developed in the river. At Boxley in early March this epilithic growth

was dominated by the green alga Tetraspora gelatinosa which is surrounded by an abundant gel.

During the course of a year of investigation into the algal growth, it became clear that there are some changes in populations from the upper to the lower Buffalo. With these changes in mind it might be possible to reduce the sampling regime to a smaller number of zones or compartments which would make sampling in one day more practical and which would also adequately represent the river. These compartments could be set up on the basis of the algal populations and the water chemistry.

Chemical parameters continued to be investigated on a monthly basis throughout this sampling period (Table 34). Some of these chemical parameters fluctuated significantly from one station to another as well as from one season to another (Fig. 36). It is important to realize that even though most of the levels are low, with the exception of silica, they are still important because of the physiological richness. One correlation which becomes obvious when studying the graphs is that both the nitrate and the silica concentrations decrease with the development of the autumn-winter epilithic diatom population. There is one chemical factor, the ammonium, which is continuously low. Between the months of May and December ammonia concentrations were measured directly using the Orion selective ion probe. Because the concentrations were beyond the lower limits of accurate measurement by the direct method, a standard addition method was instituted. This standard addition method works on the principle of moving the concentration of the sample into a more easily measurable range by adding a known volume of

a known concentration of standard to the sample. The known addition method proved though to be more difficult than the direct method and no significant data were derived. It is interesting to note that these levels are consistently low at all stations and in all seasons measured, suggesting that ammonia is probably not associated with the seasonal succession of the algae in the Buffalo River. The chemical and physical data collected have been presented to Dr. David Parker for further interpretation. These data will also be included in a Master of Science thesis (LLR).

CONCLUSION

After a seasonal qualitative analysis of the algae there are certain patterns which have been discovered. Most populations are substrate specific, for instance, those epiphytic genera which occur only in the spring and summer when vascular plants are growing in the river. These epiphytic populations, when they occur, are more or less consistent along the length of the river. Other patterns are formed by genera which are seasonal because their growth is stimulated by temperature and light. There are also algae which occur exclusively in riffle or pool habitats. With all of these kinds of restrictions present, the total aspect of the river appears quite complex.

TABLE 33

Temporal and Spatial Distribution of the Algae in the Buffalo River, 1974-75

Key to Stations

symbol	location
1	Boxley
p	Ponca
2	Pruitt
3	Jasper
4	Hasty
5	Gilbert
6	Highway 14 Bridge
7	Buffalo Point
8	Rush

taxon/date	1 July Stations P34	24 July Stations 2345678	19 August Stations P2345678	21 September Stations 1P2345678	21 October Stations 1P2345678	27 November Stations 1P2345678	17 December Stations 1P2345678	24 January Stations 1P2345678	8 March Stations 1P23456789	12 April Stations 1P23456789
CHLOROPHYCEAE										
VOLVOCALES										
Branchiomonas	P									
Chlamydomonas	P 3	5	4		1 4					
Eudorina			2							
Gonium	P			5						
Lobomonas	P									
Nephroselmis										
Pandorina			8							
Spondylosium	P									
TETRASPORALES										
Apiocystis					1					
Gloeocystis		5 8	3			P			3	
Palmella										
Sphaerocystis	P	4	4							
Tetraspora										
CHLOROCOCCALES										
Ankistrodesmus	3	2345 8	3				3 5 7		1 2	
Closteridium	P	3 4	P							
Coelastrum		3								
Crucigenia	4				1				1	
Dictyosphaeridium		3								
Golenkinia	P 3									
Kirchneriella	P	5 7								
Pediastrum		2 46	P 34 67			P 5				
Planktosphaera	P	56								
Quadrigula										
Scenedesmus	P34	2345 7	34 67	8	1 4 8			23	6	
Selenastrum	P 4					P				
Tetraedron	P	6 7								
Treubaria	34									
ULOTRICHALES										
Ulothrix							P 8	1P		P 4 8
Uronema		5								
CHAETOPHORALES										
Aphanochaete				7	2 8					
Chaetophora			6							
Oemontia	3									
Gongrosira		234567	P2 5		6	6				
Stigeoclonium		5 8		1	1	5 78	P 8	1P2 678	P	1P23 8
CLADOPHORALES										
Cladophora	3	23	7		6			P 56	2 45	
Rhizoclonium	P 34			5 78	8					
OEDOGONALES										
Bulbochaete			P2 67	5	2 45678			1 8		
Oedogonium	P	2345 78	P 5678	12 5 78	12 45678	2 4	1P	1		1 3
CONJUGATOPHYCEAE										
ZYGNEMATALES										
Mougeotia	P	2 45678	23 5678	12 45 78	1 2 7	2	1 23	1P 2		1
Sirogonium					1					
Spirogyra	P34	345678	234567	2 5	1 2 4 6 8		2	1		1 4
Zygnema		6 8		5 78						
DESMIDIALES										
Cosmarium	P34	23 567	34 7	5	12 4	1P2 5	2 4 7	1P234	1P2 4 8	1 8
Closterium	P		4	8		P	2345	P2 456	34	1P
Spondylosium			8							
Staurastrum	P					1P	7	56	1 4	
Staurodesmus	P				1 4	5	1 2345	1P2345 7	2 5	
MESOTAENIALES										
Cylindrocapsa		3 5					P 2			
EUGLENOPHYCEAE										
EUGLENALES										
Euglena					78					
Lepocinclis			4							
Phacus			4		8					
Strombomonas			4							
Trachelomonas	P		4							
PYRRHOPHYCEAE										
DINOCAPSALES										
Tetradinium	P									
PERIDINIALES										
Ceratium										
Peridinium										

taxon/date	1 July Stations P34	24 July Stations 2345678	19 August Stations P2345678	21 September Stations 1P2345678	21 October Stations 1P2345678	27 November Stations 1P2345678	17 December Stations 1P2345678	24 January Stations 1P2345678	8 March Stations 1P2345678	12 April Stations 1P2345678
CHLOROPHYCEAE										
VOLVOCALES										
Branchiomonas	p									
Chlamydomonas	p 3	5	4		4					
Eudorina			3							
Gonium	p			5						
Lobomonas	p									
Nephroselmis										
Pandorina			8							
Spondylosium	p									
TETRASPORALES										
Apiocystis					1					
Gleocystis		5 8	3							
Palmella						p			2	
Sphaerocystis	p	4	4							
Tetraspora										
CHLOROCOCCALES										
Ankistrodesmus	3	3345 8	3				3 5 7		1 2	
Clostridium	p	3 4	p							
Coelastrum		5								
Crucigenia	4				1				1	
Dictyosphaeridium		2								
Golenkinia	p 3									
Kirchneriella	p	5 7								
Pediastrum		2 45	p 34 67			p 3				
Planktosphaera	p	56								
Quadrigula										
Scenedesmus	p34	2345 7	34 67	8	1 4 8					
Salanastrum	p 4					p		23	6	
Tetraedron	p	6 7								
Treubaria	34									
ULOTRICHALES										
Ulothrix							p 8	1p		p 1 7
Uronema		5								
CHAETOPHORALES										
Aphanochaete				7	2 8					
Chaetophora			6							
Gomontia	3									
Gongrosira		234567	p 2 5		6	6				
Stigeoclonium		5 8		1	1	3 78	p 8	1p2 678	p	1p33 8
CLADOPHORALES										
Cladophora	3	23	7		6			p 56	3 45	
Rhizoclonium	p 34			5 78	8					
OEDOGONALES										
Bulbochaete			p 3 67	5	3 45678			1 8		
Oedogonium	p	2345 78	p 5678	1 2 3 78	1 2 45678	34	1p	1		1 3
CONJUGATOPHYCEAE										
ZYGNEMATALES										
Mougeotia	p	3 45678	23 5678	1 2 45 78	1 2	3	1 23	1p 2		
Sirogonium										
Spirogyra	p34	345678	234567	2 5	1 3 4 6 8		2	1		1 4
Zygnema		6 8		5 78						
DESMIDIALES										
Cosmarium	p34	2 567	34	5	12 4	1p3 5	2 4 7	1p234	1p2 4 8	
Closterium	p		4	8		p	2345	p2 456	34	1p
Spondylosium			8							
Staurastrum	p					1p	7	56	1 4	
Staurodesmus	p				4	5	1 2345	1p3345 7	2 5	
MESOTAENIALES										
Cylindrocapsa		3 5					p 3			
EUGLENOPHYCEAE										
EUGLENALES										
Euglena					78					
Lepocinclis			4							
Phacus			4		8					
Strombomonas			4							
Trachelomonas	p		4							
PYRRHOPHYCEAE										
DINOCAPSALES										
Tetradinium	p									
PERIDINALES										
Ceratium										
Peridinium										

CRYPTOMONOPHYCEAE										
CRYPTOMONADALES										
Cryptomonas	p34									
XANTHOPHYCEAE										
HETEROSIPHONALES										
Vaucheria					6	8				
CHRYSOPHYCEAE										
CHRYSOMONADALES										
Mallomonas			6							
Uroglena	p									
OCHROMONADALES										
Anthophysis	p3									
BACILLARIOPHYCEAE										
CENTRALES										
Cyclotella	p24	2 5	2					p2		
Melosira	p34	234 678	4 678	1 2 4 78	1 2 45678	1p 345678	1p224567	1p2256	1p2345678	1p2245678
Stephanodiscus			2 5							
PENNALES										
Achnanthes		2	p24567			1p234 78	1p 3456	78	1p 2	p2 456
Amphipleura	4	234	p 67	4 8			4	p2 8	p2 4 6	p
Amphora			8							
Caloneis	2					45				
Cocconeis	p24	22 56	p2245678	5 78	1 3 678	1p 4 6 8	1p2545 78	1p234 678	1p234567	1p234567
Cymatopleura				7	8		45 7			2
Cymbella	p24	234	p2345678	1 234 78	2345678	1p2245678	1p2545678	1p2565678	1p2245678	1p2345678
Diatoma	4		2 4 7			1 234567	2245678	p2368628	1p236867	2345678
Diploneis					7	4		4		
Epithemia	p34	2 4 8	p2345678	1 2 45 8	1 2 5678	56 8	1 4 78	1p 7	1 2 4 67	4
Eunotia		5			2 567		5	4		
Fragilaria	p 4	234567	p234 678	5678	1 2 4 7	1p224567	1p2545678	p2345678	1 25 5 78	1p2545678
Frustulia	4	4	7		78	2245 7	2 7	2 7		1
Gomphonema	p5	2 5 7	p224567	1 45 78	1 2 45 78	1p 45 8	p2 45 7	p2 4 678	1 2 4 7	2 4 6
Gyrosigma	p 4	34 8	8	8	8	45				
Mastigloia				8	2 7					
Meridion						1p 54 8	1p224567	1p23456	1p 56 8	1p2 45 7
Navicula	p34	2	p2345678	1 2 7	3 5 78	1p2545678	1p2545678	1p2545678	1p2545678	1p 234567
Nedium			2 8			2 45 8	78			
Nitzschia	p 4	2	p 345678	1 2545 78	1 2245 7	1p2345678	1p2545678	1p 45678	1 345678	1p2345 7
Opephora		23 8								
Pinnularia		2 4	p 456 8	1 2 8	2					
Pleurosigma	p5	2	4 6		2	p2	4 7	4	2	
Rhopalodia	p 4	2 4 8	p2545678	2 5 78	1 4 78	1 2345 8	1 2 5 8	1p2 4	4	1
Stauroneis	p		4		8					
Surirella	p3	2 4 8	p2 45678	8	7	1p 5456	1p 54 78	1p2545 7	1p2245678	1p2245678
Synedra	p34	678	p5545678	1 22 5678	1 4 8	1p25 5 78	1 22 5 7	1p254567	1p25456 8	1p 4 67
Tabellaria								2		
CYANOPHYCEAE										
CHROOCOCCALES										
Anacystis		8								
Aphanocapsa			p 6							
Chroococcus		5	56							
Entophysalis		2 8	p							
Gleocapsa	4	4	7		1 23 56			2	1 3	2 8
Merismopedia										
Microcystis	p2	2345 7	4 7				7	1p		
Polycystis	p	345 8	4 78							
CHAMAESIPHONALES										
Chamaesiphon	3	45	6	5 8	8					
OSCILLATORIALES										
Anabaena	34	5	78							
Autosira		4 8								
Beggiatoa			23 67				54 6	p 45	1p22 5 7	1p23 5 7
Calothrix			p2 56 8	1 4	1 2 56 8	2 6		1		
Gleothece										
Gleotrichia	2									
Haplosiphon										
Homothrix		2 5 7								
Lyngbya	p24	4567	p234 6 8	1 6	1 5 7	2	1	1p7 5 8	2 6	p23456
Microcoleus										
Nostoc		34	p		7					
Oscillatoria	p34	2245 7	4 678	1 4 6 8	345 78	1p234 6	1p 2456 8	1 23 78	1p23456	1p2345678
Phormidium		2 4567	5 8			8				
Schizothrix		2								
Scytonema										
Spirulina	p3	4	6	6	8					
Tolypothrix			p2		8					1
Trichodesmium		5								

Table 34
Range and Mean Values of Chemical and Physical Data from the Buffalo River, 1974-75

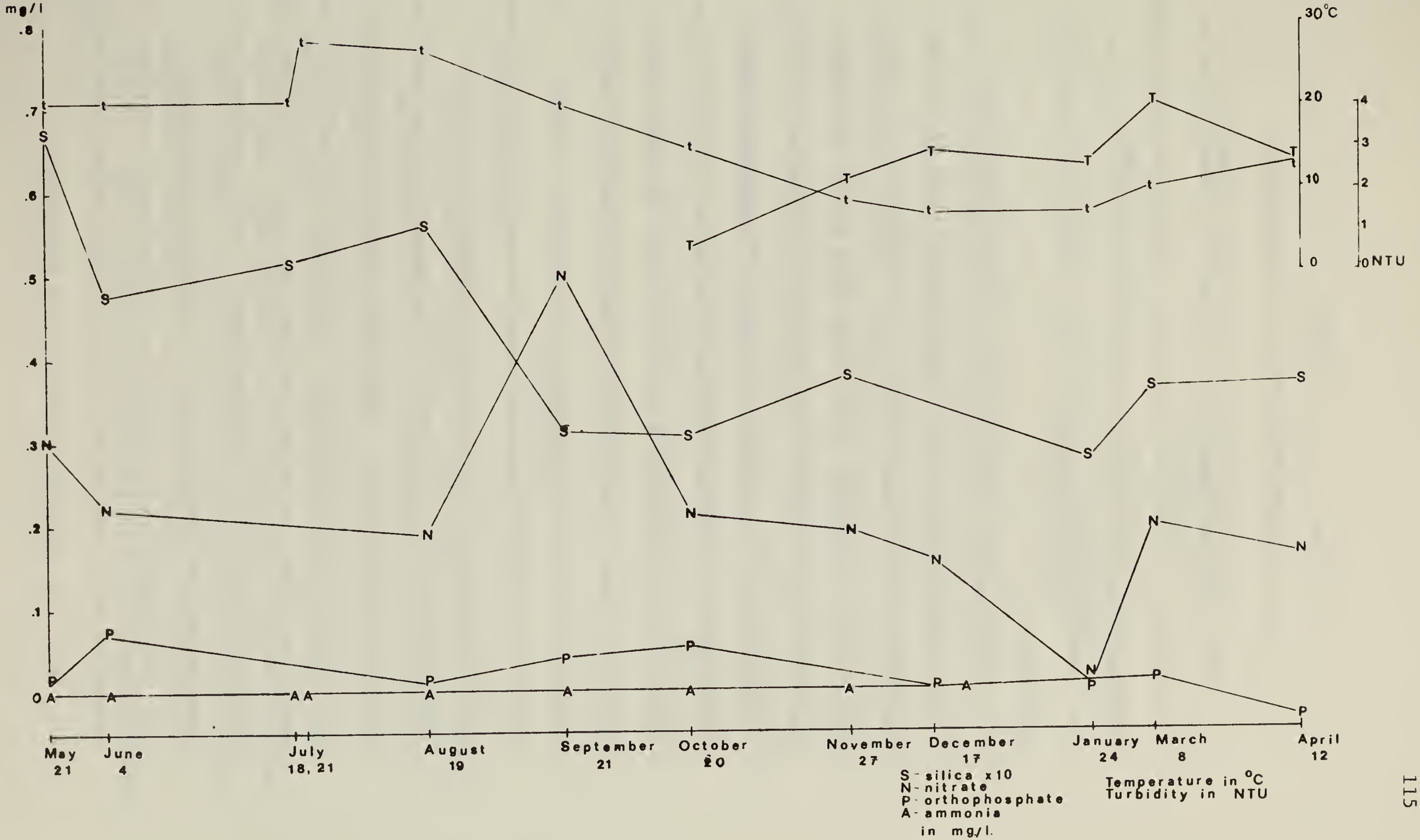
Date	Origin	Temperature °C	Turbidity NTU	Ammonia-N mg/1	Nitrate-N mg/1	Ortho Phosphate-P mg/1	Silicates mg/1
21 May	Parker	17-22 21		0.002-0.003 0.003	0.22-0.36 0.03	0.006-0.033 0.010	
4 June	Parker	19-24 21		0.003-0.006 0.005	0.20-0.27 0.22	0.065-0.080 0.073	4.63-4.97 4.75
18 July	Parker	19-22 21					4.77-5.62 5.17
24 July	Meyer	24-32 28					
19 August	Meyer	24-30 28		0.002-0.003 0.002	0.16-0.24 0.19	0.006-0.036 0.012	1.22-7.47 5.69
21 September	Meyer	18-22 20		0.003-0.006 0.004	0.24-0.75 0.50	0.016-0.082 0.039	2.49-3.68 3.12
20 October	Meyer	14-20 15	0.29-0.91 0.63	0.002-0.004 0.003	0.16-0.28 0.21	0.115-0.354 0.152	2.39-3.77 3.05
27 November	Meyer	6-10 8.7	1.0-5.50 2.14		0.12-0.28 0.19		3.498-4.039 3.727
17 December	Meyer	5-7 6.4	1.70-5.25 2.82	<.001-0.005 0.002	0.00-0.238 0.152	0.000-0.008 0.000	2.956-3.807 3.376
24 January	Meyer	6-8 6.8	1.70-4.00 2.52		0.00-0.003 0.001	0.001-0.018 0.007	2.03-6,48 2.73

Range Values continued

Date	Origin	Temperature °C	Turbidity NTU	Ammonia-N mg/l	Nitrate-N mg/l	Ortho Phosphate-P mg/l	Silicates mg/l
8 March	Meyer	9-11 9.9	1.5-7.5 4.02		0.133-0.241 0.195	0.005-0.013 0.009	2.87-4.55 3.59
12 April	Meyer	9.0-15.5 12.83	1.20-4.20 2.64		0.034-0.083 0.061	0.011-0.024 0.015	3.32-4.27 3.67

Figure 36

Mean Values of Chemical and Physical Data vs. Time



LAND USE

H. MacDonald and Stephen C. Hurley

This section of the report is intended to identify the use of land within the Buffalo River basin. Through analysis of remote sensing data, existing land use patterns within the basin have been identified on the included Buffalo National River Land Use Map (Plate 1).

Remote sensors including aerial cameras are merely the tools for gathering land use data. Remote sensing data used for the identification of current land use were obtained by panchromatic large scale aerial photography, color large scale aerial photography, panchromatic photo-mosaics, and Earth Resources Technology Satellite (formerly ERTS-1, now LANDSAT-1) imagery. Panchromatic aerial photographs at a scale of 1:20,000 were obtained at no cost to the project from the Arkansas Highway Department (the cooperative efforts of Roger F. Taylor, Photogrammetrist, and R. H. Mattox, Engineer of Surveys, are graciously acknowledged). Ninety percent of this photography was imaged during 1972-1973, the remainder (10%) during 1968. The color aerial photographs at a scale of 1:10,000 were taken during 1973 by Tobin Research Incorporated for the National Park Service. These large scale color photographs were restricted to the confines of the Buffalo National River itself and did not cover the entire river drainage basin. The LANDSAT imagery obtained in 1972-1973. The photo-mosaics (scale 1:63,000) were taken during 1965-1966 for the U.S. Department of Agriculture.

The classification used for the land use maps is the Level II classification of the United States Geological Survey (USGS Circular 671, 1972). The following categories are recognized.

Level I	Level II
Agricultural	(21) Agricultural
Forest Land	(41) Deciduous (42) Evergreen (43) Mixed
Urban and Built-up	(11) Residential (17) Strip and Clustered Settlement (12) Commercial (13) Industrial

This classification at the first and second levels is general in order to facilitate the use of remote sensing data. Satellite imagery and photography at a scale of 1:20,000 are adequate for the recognition and delineation of these categories. Generalization allows for minimal reliance on supplemental information at the first and second levels of categorization. The classification is open ended, so that if a more detailed land use classification at the third and fourth levels is later desired it will be compatible within the existing framework.

DEFINITIONS

Agricultural (21)

Agricultural land includes that used primarily for production of farm commodities and the land associated with that production. The cleared fields which constitute crop land and pasture are generally easy to recognize, particularly when juxtaposed with forest land, which is most often the case within the Buffalo River basin. Symmetrical patterns on the landscape, caused by mechanized equipment, often serve as a reliable indicator of agricultural activity. The interface of Agricultural land with other categories

of land is sometimes a zone of transition or intermixture. However, within the basin this causes few difficulties as most boundaries are readily recognizable. Cropland and pasture are combined as Agricultural land because from imagery alone it is not possible to make a distinction with a high degree of accuracy and uniformity.

Pasturage constitutes the dominant use of Agricultural land within the Buffalo River basin, although some crops are grown. Farms are generally small (less than 100 acres), and usually occupy river valleys and flat-topped upland surfaces.

Forest Land

Forest lands are those that are at least 10 percent occupied by trees capable of producing timber or wood products, and that exert an influence on the climate or water regime. Included are lands from which trees have been removed, but which have not been developed for other use. Forest land is generally easy to recognize from remote sensing imagery, although the boundary between it and other categories may in some cases be difficult to delineate precisely.

Forest land is divided into three Level II categories: Deciduous, Evergreen, and Mixed. Differentiation of the three requires sequential imagery or imagery during the period when deciduous trees are bare. When the deciduous trees are bare tonal contrasts are visible on the aerial photographs. On the panchromatic aerial photographs evergreen areas appear as dark tones, whereas the deciduous areas are a light gray; therefore, the delineation of these areas is easily accomplished. When the leaves are present on the deciduous trees the contrast in tone is more subtle, and consequently recognition is difficult or

impossible with any degree of accuracy. These conditions do not apply for large scale color aerial photographs and the various categories of Forest land can be identified rather easily.

Deciduous (41)

Deciduous Forest land is that in which the trees are predominantly those from which the leaves fall at the end of the growing period. Of course, imagery taken during the winter months is desirable for the detection of Deciduous Forest.

In the basin Deciduous Forest is dominantly of the oak-hickory type occupying the uplands. Floodplains are typically occupied by sweetgum, elm, willow, birch, sycamore, and boxelder.

Evergreen (42)

Evergreen Forest land may be defined as all forest areas in which the trees are predominantly those which remain green throughout the year. Again, aerial photographs taken during the winter months are desirable because the tonal contrast between the deciduous and evergreen trees makes recognition more apparent.

Red cedar and shortleaf pine are the dominant evergreen types within the Buffalo River basin. The shortleaf pine, while not indigenous to this area, has been introduced by the National Forest Service. The Forest Service commonly clears large blocks of land in the National Forest, replacing the deciduous trees with shortleaf pine. These symmetrical patterns are easily identified from aerial photographs.

Mixed (43)

Mixed Forest land includes all forest areas where both evergreen and deciduous trees are growing and neither predominates. It is a more than one-third intermixture of either evergreen or deciduous species. Less than one-third intermixture results in classification of the dominant type, whether evergreen or deciduous.

Urban and Built-Up

Urban and Built-up land includes areas of intensive use with much of the land covered by structures. In the rural and sparsely populated Buffalo River basin Urban and Built-up land categories do not predominate. However, where they do, these categories are easily identified as the structures are recognizable from aerial photographs at a scale of 1:20,000 and because of the generally symmetrical shape of the area.

The Urban and Built-up categories take precedence over other categories of land use where the criteria for more than one category are met. Thus, isolated farm plots surrounded by Urban and Built-up land would be classified as Urban and Built-up land.

Four Level II categories of Urban and Built-up land are recognized within the Buffalo River basin. These include Residential, Strip and Clustered Settlements, Commercial, and Industrial land uses.

Residential (11)

Residential land use ranges from high density to low density housing. It is found in populated areas where residential housing can be separated from other Urban and Built-up categories.

In the Buffalo River basin, the Residential category is limited to the town of Marshall. It is the only town with sufficient population and areal extent for the above qualifications to be met.

Strip and Clustered Settlements (17)

The Strip and Clustered Settlements category includes small towns, developments along transportation routes, and built-up areas where separate land uses may not be distinguishable. Generally this category is restricted to small towns such as Jasper, Big Flat, Gilbert, Mount Judea, and Ponca. Towns such as these are too small for the various categories of Urban and Built-up land to be identified; therefore, in these instances the entire town is classified as Strip and Clustered Settlements. From aerial photographs at a scale of 1:20,000, small towns are easily recognized.

Commercial (12)

Commercial areas include those used predominantly for the sale of products and services. Most of the towns within the Buffalo River basin are too small for the category to be separated from other Urban and Built-up categories. Only in Marshall can the Commercial category be effectively separated from other categories. Dogpatch, U.S.A. is the only other occurrence of commercially used land within the basin.

Industrial (13)

Industrial areas are those in which manufacturing takes place. Mining is also included in this category. In the Buffalo River

basin, the Industrial category is limited to rock quarries and lumber mills. Quarries are included for convenience in this category rather than Extractive because of the limited number within the basin.

Certain obstacles were encountered during the interpretation of the imagery and the designing and drafting of the land use map. Because a base map of the Buffalo River basin was unavailable, it was necessary to construct one. Topographic maps at a uniform scale do not exist for the entire basin. The only adequate maps (usable size and scale) were Arkansas Highway Department County Highway Maps; therefore, these county highway maps were used for the construction of the base map. These county highway maps are at a scale of 1:120,000. Because of the large size of the Buffalo River basin, and consequently the base map, it was necessary to have the compilation-scale land use map reduced in size to a scale of 1:190,000 (Plate 1).

The next step in the construction of the land use map was the collection and analysis of the imagery covering the basin. From the ERTS imagery it was possible to identify land use categories at the Level I classification. The ERTS imagery is recorded with a four band line scanning device operating in the visible and near-infrared portions of the spectrum. The four bands are 0.5-0.6 (band 4), 0.6-0.7 (band 5), 0.7-0.8 (band 6), and 0.8-1.1 (band 7) microns. Band seven (0.8-1.1 microns) provides a near-infrared capability that is particularly useful for recognizing vegetation. The ERTS imagery available for this study was obtained

during the months of August (1972) through February (1973) utilizing band 5 (0.6-0.7 microns). One color composite taken in December 1972 and utilizing bands 4, 5, and 7 was available for the western two-thirds of the basin. The ERTS imagery was at a scale of 1: 1,000,000. Because a Level II classification was desired, the Level I categories identified from the ERTS imagery were not actually drafted onto the land use map. However, the ERTS imagery did provide a synoptic view of the Buffalo River basin, thus allowing Agricultural and Forest land and Urban and Built-up land to be quickly and accurately identified. For land use interpretation of ERTS imagery the time of year and spectral band of coverage are particularly important. As land use patterns are sometimes obscure and vary with the time of year, temporal imagery or at least imagery from each season is desirable. For example, deciduous trees vary in appearance seasonally. Several different spectral bands in conjunction with the time of coverage are necessary to allow for maximum comparisons of land use which varies seasonally. Because of limited funding these advantages were not available.

Following analysis of the ERTS imagery the photo-mosaics were inspected. The 1:63,000 scale of these photographs is not compatible with that of the base map. The photo-mosaics were combined to provide complete coverage of the entire basin. Because of the date of coverage (1965-1966) and the format of presentation (photo-mosaics), these photographs were not used for identification of land use, except when comparisons were needed for problem areas or where the quality of the other photographs was poor.

The primary data source used for the land use identification was the large scale panchromatic aerial photographs. The scale of these photographs is 1:20,000 and that of the base map 1:120,000; therefore, one must allow for this change in scale when drafting the land use categories onto the base map. Where available, stereo coverage allowed improved interpretation with stereoscopic viewing. Monoscopic magnification of up to 20 times was used for closer inspection of problem areas. Land use categories, once determined from these photographs, were drafted directly onto the base map.

There are certain inherent limitations with the land use map (Plate 1). Aerial photographs taken during the winter months were not available for the eastern one-third of the basin. Photographs of the eastern one-third of the basin were taken during May. Deciduous trees have foliage in May; as the result, it is difficult, if not impossible, to differentiate between Deciduous, Evergreen, or Mixed Forest types because the gray tones, which are indicative of forest type, are similar. In these cases, identification of forest type was aided by consulting the 1972 Ozarks Regional Land Use Maps of the area.

The Buffalo River basin is contained within the Ozarks Regional Land Use Maps of the Harrison and Russellville, Arkansas, quadrangles. These land use maps have the advantage of a statistical format; thus the information available can be quickly recalled and analysed. However, certain drawbacks exist with these Ozarks Regional maps. Both the Harrison and the Russellville land use identifications are from a 1968 data source. Because a polygonal system was used to transfer identified land uses onto the actual map, the mapped

categories are generalized with respect to shape and extent. These maps were at times found to be inconsistent in identification and classification of land use. For instance, forest which is classified as Evergreen Forest land in one area might be recognized as Deciduous or Mixed Forest land in another area. The land use map prepared for this study is the superior land use map because of the above factors, and because it is more detailed.

Exact geographic positioning and size of land use categories were affected because of the transfer involved from the relatively large scale photographs to the small scale Buffalo River basin base map. Also, because the date of photographic coverage available was no more recent than 1972-1973, minor land use changes might be anticipated.

DEVELOPMENT SITES

Color aerial photographs (scale 1:10,000) were used almost exclusively for the recognition of land use categories for the proposed development sites. The development site locations were provided by Mr. Donald M. Spalding, Superintendent, Buffalo National River. Because individual segment maps were drafted from these photographs, the maps obviously provided an adequate base for annotating the land use categories. The development sites are as follows: Buffalo Point - Highway 14, Carver, Kyle's Landing, Lost Valley, Ponca, Pruitt, Rush, Tyler Bend - Highway 65, and Woolum.

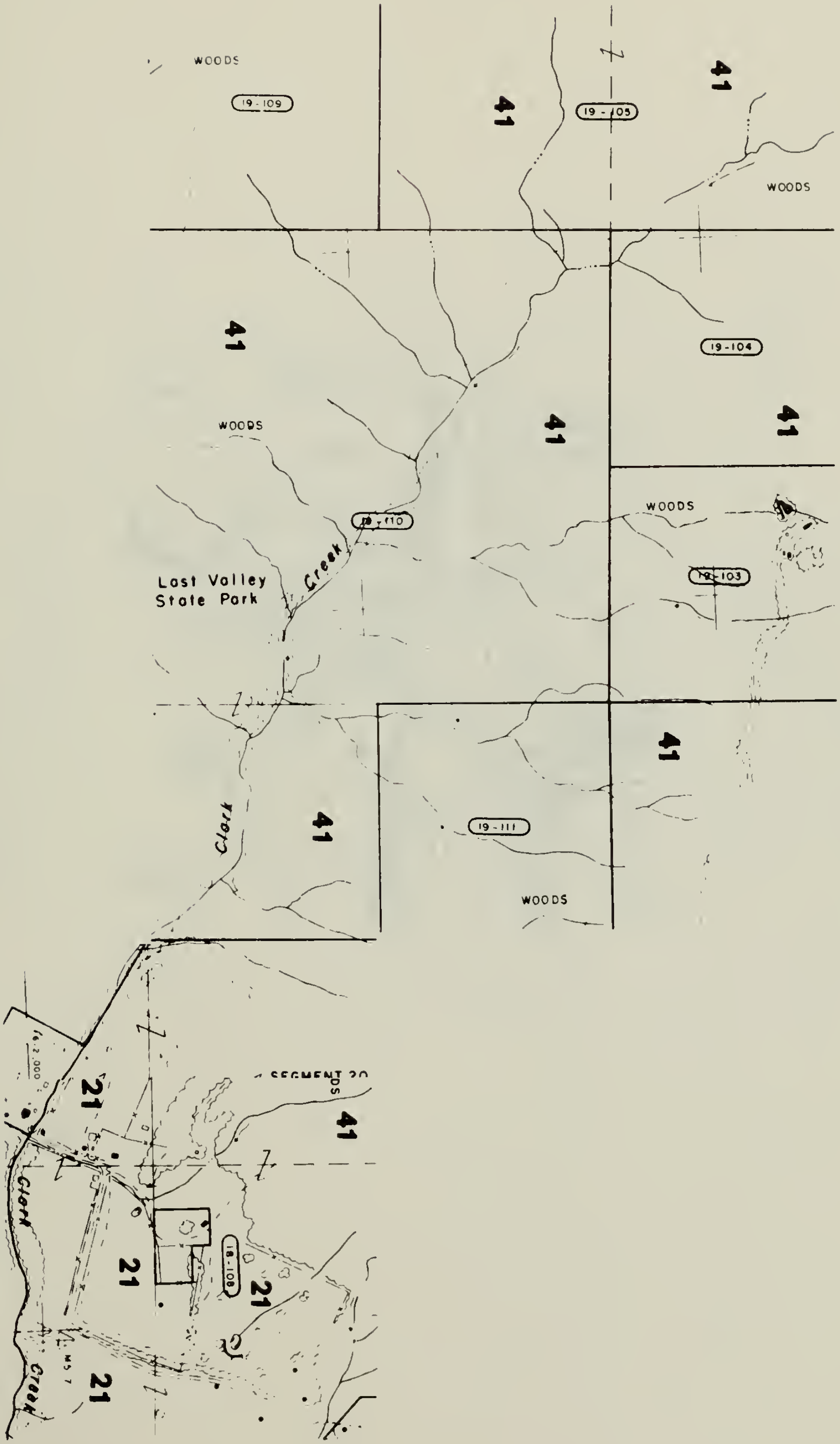
DEVELOPMENT SITES

BUFFALO NATIONAL RIVER

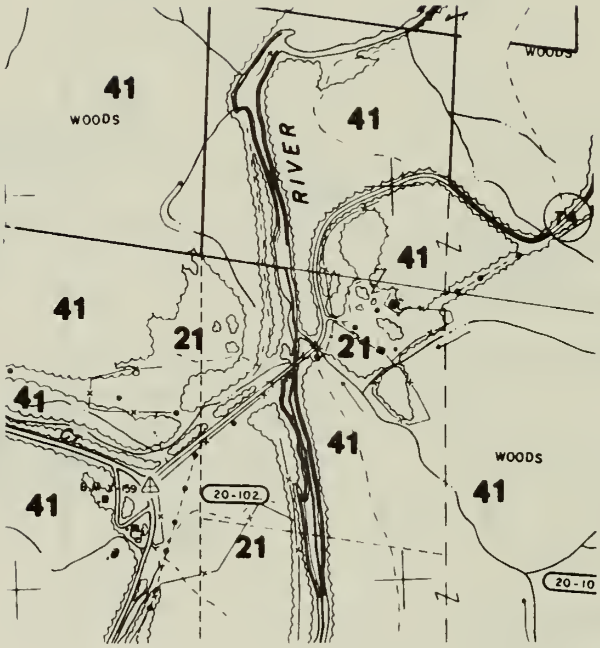
LAND USE LEGEND

AGRICULTURAL	(21) AGRICULTURAL
FOREST LAND	(41) DECIDUOUS
	(42) EVERGREEN
	(43) MIXED
URBAN AND BUILT-UP	(11) RESIDENTIAL
	(17) STRIP AND CLUSTERED SETTLEMENT
	(12) COMMERCIAL
	(13) INDUSTRIAL

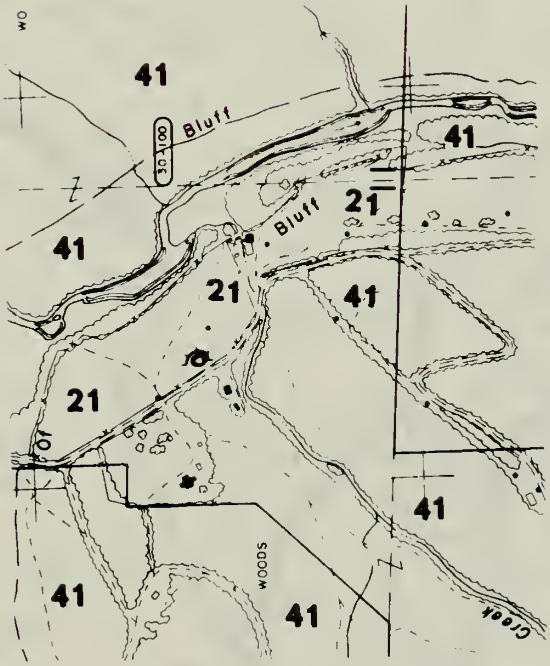
LOST VALLEY


WOODS
19-109
41
19-105
41
WOODS
41
19-104
41
WOODS
41
WOODS
19-110
Lost Valley
State Park
Creek
WOODS
19-103
41
Clark
41
19-111
WOODS
SEGMENT 20
21
41
Clark
21
18-108
21
21
Creek

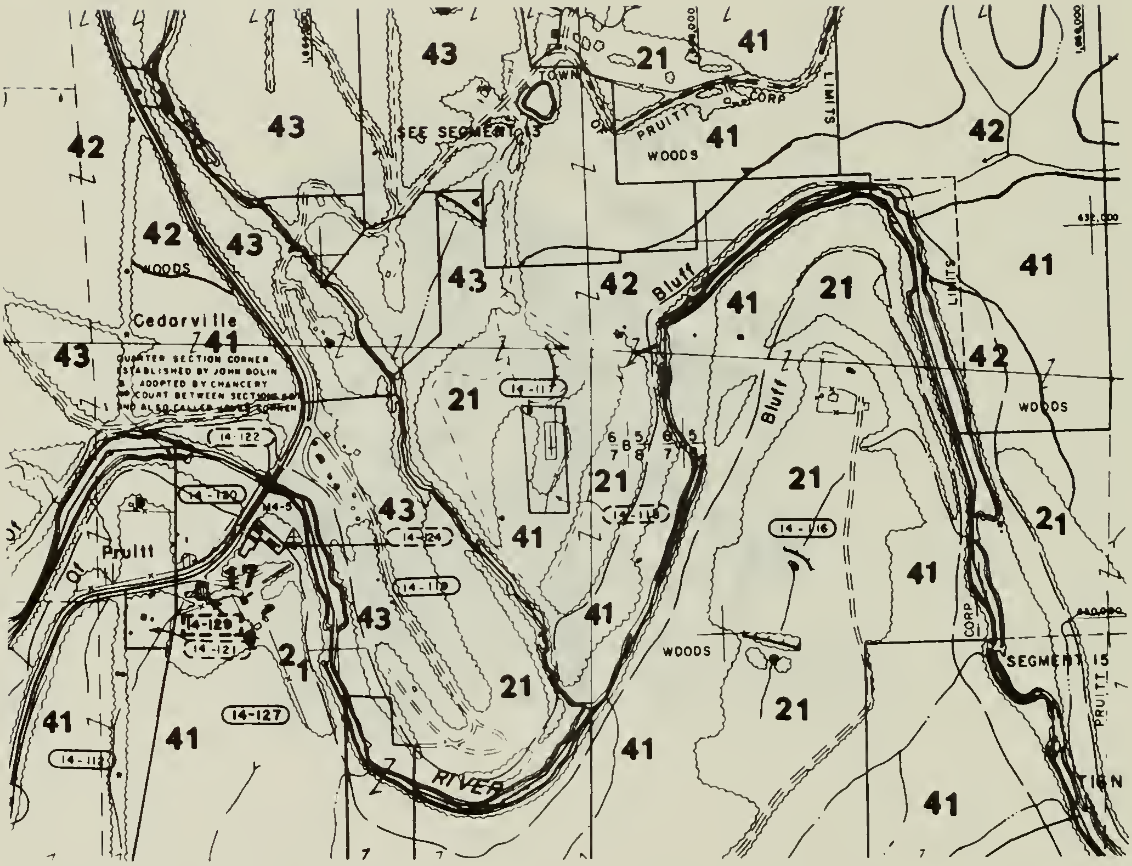
P O N C A


41
WOODS
41
RIVER
WOODS
41
41
21
21
41
41
WOODS
41
41
20-102
21
20-10

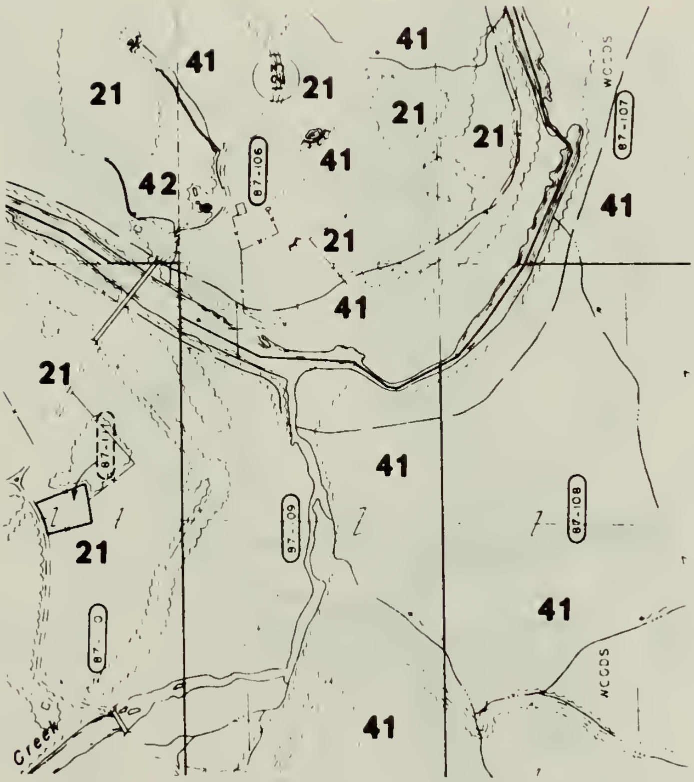
KYLE'S LANDING



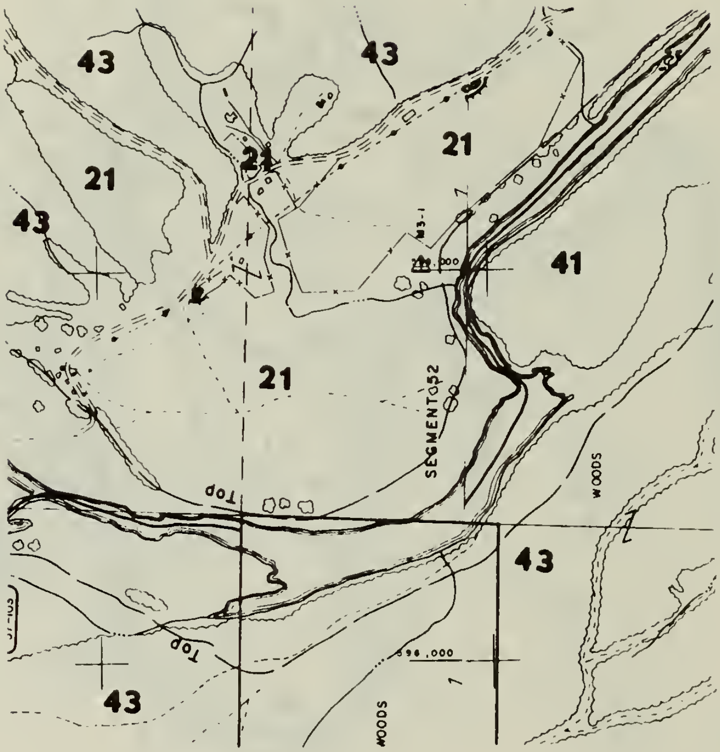
PRUITT


43
21
41
42
TOWN
SEE SEGMENT 13
PRUITT
CORP
LIMITS
WOODS
Bluff
Cedarville
QUARTER SECTION CORNER ESTABLISHED BY JOHN BOLIN & ADOPTED BY CHANCERY COURT BETWEEN SECTIONS AND ALSO CALLED LOVES CORNER
14-122
14-117
14-120
14-124
14-118
14-116
14-119
14-129
14-121
14-127
14-112
Pruitt
17
RIVER
SEGMENT 15

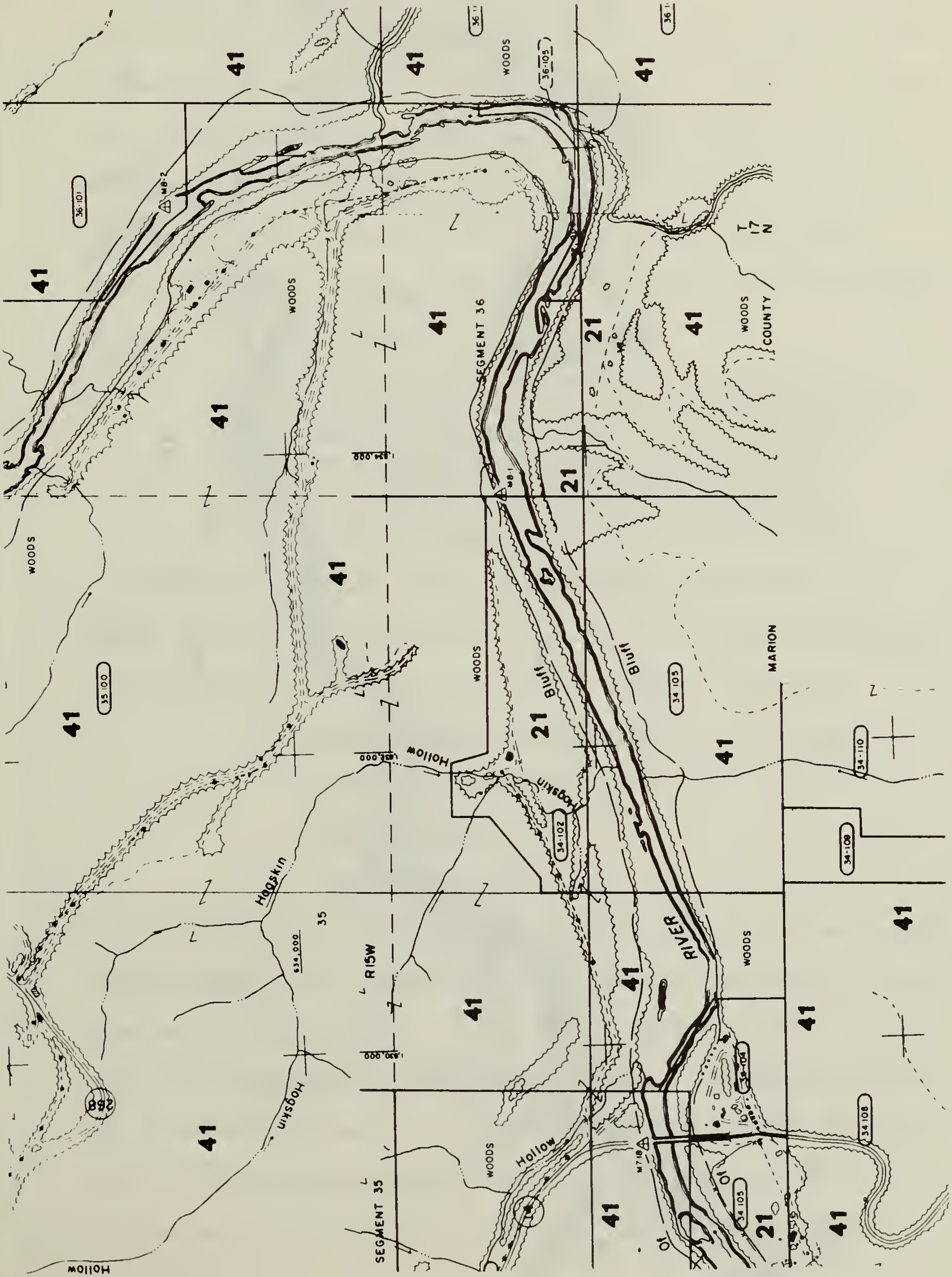
C A R V E R


41
21
41
21
21
21
42
87-106
41
87-107
41
21
41
21
87-111
41
21
87-108
41
41
Creek

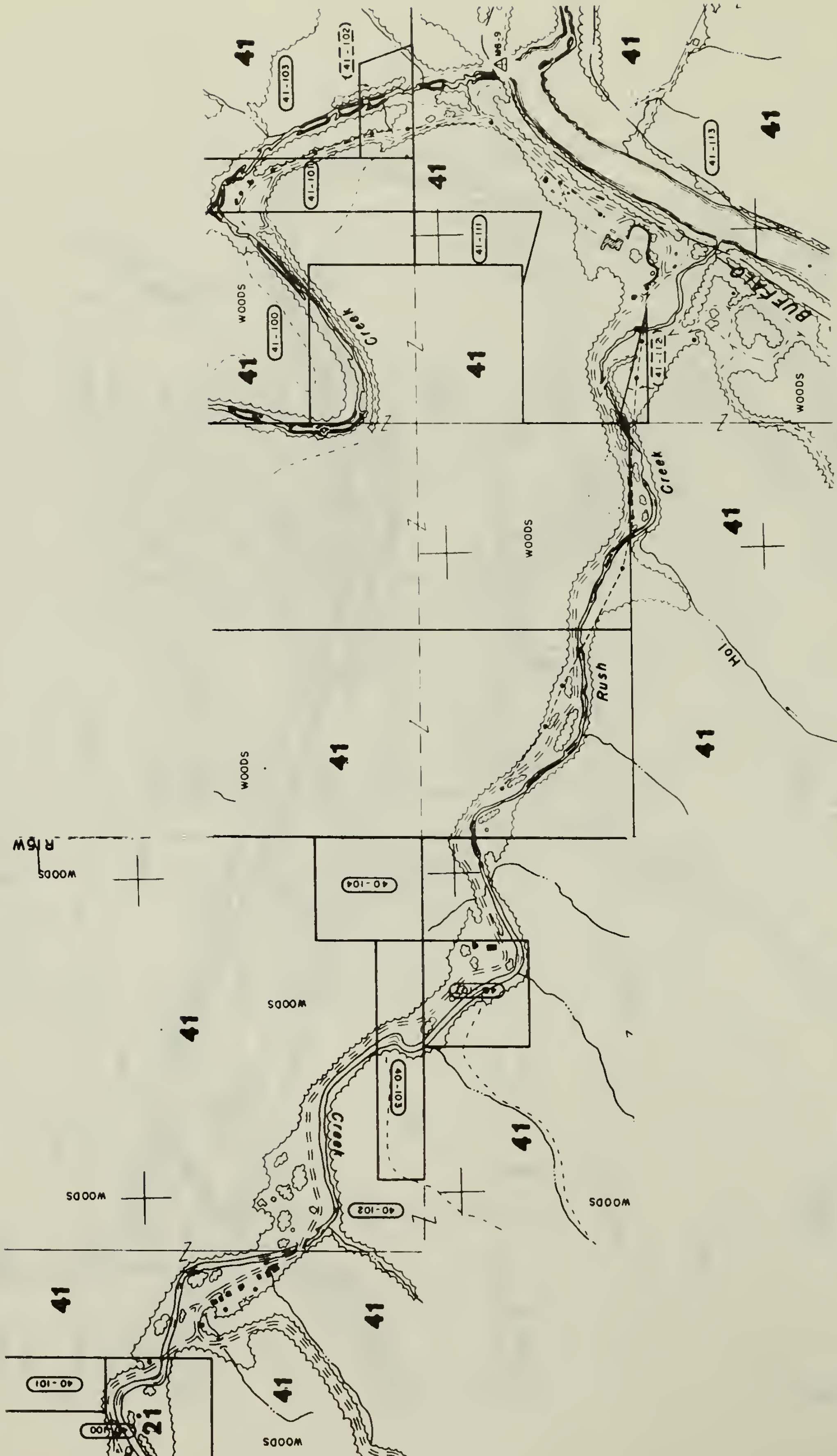
W O O L U M



BUFFALO POINT - HIGHWAY 14



RUSH



41
41-103
41-102
41-101
41-100
41-111
41-112
41-113
40-104
40-103
40-102
40-101
21
WOODS
Creek
Rush
Creek
BUFFALO
R16W

RESOURCE CAPACITY

Principal Investigators: R. E. Babcock, D. G. Parker

The evaluation of the resource capacity of an outdoor recreational system such as the Buffalo National River is a complex operation and involves the consideration of many diverse factors. However, superimposed upon the complexity of the problem is an additional problem of confusion and misunderstanding of the definition and use of the term "resource capacity". David Lime and George Stankey, USDA Forest Service, have made a point in the literature that should be emphasized and dealt with at the onset. This point is that:

> (Resource) capacity can be judged only in light of the particular management objectives for a given area (system). These objectives must define what type of recreational opportunity or opportunities the area is going to provide. . . Without definite objectives, trying to manage any location for its (resource) capacity will be an exercise in futility.

There are a variety of ways of classifying objectives. The Federal Water Resource Council has proposed four different objectives for evaluating water resource development projects. They are:

National Economic Development

Regional Economic Development

Quality of Life

Environmental Quality

These objectives are broad enough to encompass most objectives defined by other people. For example, the objective term "Satisfactory Visitor Experience" is really a part of the term "Quality of Life". The objective of adequately treating and disposing of the waste generated due to recreational use of a system is an integral part of the objectives of "Environmental Quality". However, the resource capacity of a system can not be evaluated until the objective has been defined.

A second point that should be taken into consideration is that these objectives are not independent but are dependent upon each other in a complicated manner. For example, selected camp sites based on a satisfactory visitor experience may be unsuitable locations for conventional septic tank installations. Unsuitable septic tank conditions have been found to exist in many areas in the Ozark mountains because of unsuitable soil types, shallow soil cover, and/or fractured bedrock.

Secondly, most sewage treatment facilities are adversely affected by variations in flow. Often days and even weeks are required for treatment plants to adjust to large variations in visitor use on weekends, holidays, and seasonal variation. Lucas points out that:

> No one recreation supplier need feel obliged to meet all demands. Each public agency could aim clearly at a part of the demand, and refer people who want something more, less or different to a more appropriate area.

The logical objective for the Buffalo National River is to maintain its relatively high water quality and asthetic value that results from its terrain, caves, waterfalls, pioneer cabins, spectacular rock formations, trees, plants, flowers, birds, animals, fishes, and native appeal. In order to quantify the resource capacity of the Buffalo National River to maintain this multi-faceted objective, the interactions among all of the above factors must be known. This is, of course, impossible with the present state of the art of environmental research. However, as a starting point one might assume that if the water quality of the river is maintained all of the other factors will remain relatively stable. Such is not the

case however. It must be admitted that any use of an ecosystem will result in some change. What must be determined is the character of the change that will occur for a given type and amount of use. Associated with this, of course, is the nature of the change with respect to longevity (i.e., permanent or temporary change). For example, the water quality may degrade substantially during heavy summer use yet recover adequately during the winter. However, plant and wildlife disturbance and destruction as a result of heavy summer use will recover little if at all during the winter rest period.

For these reasons plant and wildlife monitoring should be done as well as water quality so as to allow correlation with visitor use. A disturbance indices could then be developed that would in essence display, qualitatively at least, the combined effect of visitor use on the ecosystem and through use of a weighting system, areas of criticality could be pinpointed.

AUTOMATIC MONITORING OF WATER QUALITY DATA (OWRT Funding)

Principal Investigator: R. W. Raible

Evaluation of digital ground-based, water quality monitoring systems could not be accomplished during the designated test period (summer 1973), because of the remoteness of the area. While equipment operation was not feasible because of the logistical problems encountered, "manual" valuable data were obtained during a peak use period. Data and analyses are presented in Appendix B. This information was not available for inclusion in the preliminary water quality survey (4).

ICHTHYOFAUNA STUDY (OWRT Funding)

Principal Investigators: D. A. Becker and R. V. Kilambi
Student Assistants: Michael R. Geihsler and Jerry Y. Niederkorn

INTRODUCTION

In 1972, Congress declared the Buffalo River in northern Arkansas a National River. Prior to this declaration, no impact statement of the area had been made by any research organization. The present investigation was initiated to establish baseline information for future investigations with the following objectives:

1. A qualitative and quantitative study of the distribution and abundance of fishes at selected areas with special emphasis on species diversity. The helminth and crustacean parasites of the smallmouth bass *Micropterus dolomieui* Lacepede will also be studied relative to species diversity.

2. A study of the seasonal and annual growth cycles, age composition, mortality rates, and maximum attainable size and age of the smallmouth bass and the effects of parasitism on these parameters.

3. Correlation of the above parameters with the physicochemical data to delineate the effects of water quality.

MATERIALS AND METHODS

Fishes were collected from selected upstream, midstream, and downstream sites by electrofishing and seining.

Smallmouth bass were examined alive in the field, their ectoparasites and viscera preserved, selected morphometric measurements made, scale samples taken, and sex determined. All other fishes were identified, enumerated, and returned to the river.

The physicochemical parameters of air and water temperatures, dissolved oxygen, pH, and stream velocity were measured.

Endoparasite recovery from the preserved viscera of smallmouth bass is being carried out in the laboratory.

RESULTS AND DISCUSSION

Table 35 summarizes the number of species collected from pools and riffles at the three selected collection sites. These data will be utilized to analyze species diversity, and correlations with the water quality parameters monitored (Table II) will be made

Table III indicates the number of smallmouth bass collected from which the helminth and crustacean parasites are being recovere These parasites will be processed for identification and the identification data will be used in species diversity analyses and correlated with water quality parameters monitored.

Smallmouth bass scale samples are being prepared for age determinations and growth analyses. These data will be evaluated with relation to water quality parameters monitored. Helminth and crustacean parasites recovered from the fish will be utilized in the analyses of the effects of parasitism on age and growth of the hosts.

The results of the above analyses will serve as baseline information concerning the relative abundance of fish species and their diversity indices. Age and growth analyses of smallmouth bass will be evaluated in terms of the effects of parasitism on these parameters. The effects of water quality parameters monitore will provide basic information for future investigations.

TABLE 35

QUALITATIVE AND QUANTITATIVE MONTHLY FISH DATA

FROM JANUARY 1974 THROUGH FEBRUARY 1975

SPECIES	Number of Fishes: Upstream Station 1 Ponca, Ark. Pool	Upstream Station 1 Ponca, Ark. Riffle	Midstream Station 2 Hasty, Ark. Pool	Midstream Station 2 Hasty, Ark. Riffle	Downstream Station 3 Rush, Ark. Pool	Downstream Station 3 Rush, Ark. Riffle	Total Pool	Total Riffle
Ichthyomyzon castaneus Girard Chestnut lamprey	0	0	0	0	0	1	0	1
Anguilla rostrata (LeSueur) American eel	0	0	1	0	1	0	2	0
Lepisosteus osseus (Linnaeus) Longnose gar	0	0	1	0	2	0	3	0
Campostoma anomalum (Rafinesque) Stoneroller	9	96	5	19	0	11	14	126
Campostoma oligolepis Hubbs and Greene Largescale stoneroller	8	58	10	555	8	115	26	728
Dionda nubila (Forbes) Ozark minnow	2	8	45	107	26	6	73	121
Hybopsis amblops (Rafinesque) Bigeye chub	41	0	32	69	8	1	81	70
Hybopsis dissimilis (Kirtland) Streamline chub	0	0	0	5	0	15	0	20
Nocomis biguttatus (Kirtland) Hornyhead chub	32	4	3	4	1	0	36	8
Notropis boops Gilbert Bigeye shiner	5	9	149	153	113	37	267	199
Notropis chrysocephalus (Rafinesque) Stripped shiner	1	0	21	2	7	0	29	2
Notropis galacturus (Cope) Whitetail shiner	8	1	1	19	2	12	11	32
Notropis greenei Hubbs and Ortenburger Wedgespot shiner	0	0	0	12	1	38	1	50
Notropis ozarcanus Meek Ozark shiner	0	0	3	2	0	0	3	2

TABLE 35

QUALITATIVE AND QUANTITATIVE MONTHLY FISH DATA

FROM JANUARY 1974 THROUGH FEBRUARY 1975

	NUMBER OF FISHES							
	Upstream Station 1 Ponca, Ark.		Midstream Station 2 Hasty, Ark.		Downstream Station 3 Rush, Ark.		Total	
SPECIES	Pool	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle
Notropis pilsbryi Fowler Duskystripe shiner	41	126	21	627	47	99	109	852
Notropis rubellus (Agassiz) Rosyface shiner	0	3	11	165	22	74	33	242
Notropis telescopus (Cope) Telescope shiner	9	17	70	192	12	0	91	209
Notropis whipplei (Girard) Steelcolor shiner	0	0	0	0	0	3	0	3
Pimephales notatus (Rafinesque) Bluntnose minnow	3	0	41	3	21	1	65	4
Hypentelium nigricans (LeSueur) Northern hog sucker	6	1	0	2	2	1	8	4
Moxostoma dequesnei (LeSueur) Black redhorse	2	0	12	3	2	0	16	3
Moxostoma erythrurum (Rafinesque) Golden redhorse	3	0	8	0	8	0	19	0
Ictalurus melas (Rafinesque) Black bullhead	0	0	0	0	1	0	1	0
Ictalurus natalis (LeSueur) Yellow bullhead	11	1	0	0	4	0	15	1
Noturus albater Taylor Ozark madtom	0	71	1	90	0	148	1	309
Noturus exilis Nelson Slender madtom	1	39	1	26	0	2	2	67
Noturus flavater Taylor Checkered madtom	1	1	0	0	0	1	1	2
Pylodictis olivaris (Rafinesque) Flathead catfish	0	0	3	0	3	0	6	0

TABLE 35

QUALITATIVE AND QUANTITATIVE MONTHLY FISH DATA

FROM JANUARY 1974 THROUGH FEBRUARY 1975

	NUMBER OF FISHES							
	Upstream Station 1 Ponca, Ark.		Midstream Station 2 Hasty, Ark.		Downstream Station 3 Rush, Ark.		Total	
SPECIES	Pool	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle
Fundulus catenatus (Storer) Northern studfish	3	0	2	2	4	1	9	3
Fundulus olivaceus (Storer) Blackspotted topminnow	0	1	9	0	7	0	16	1
Labidesthes sicculus (Cope) Brook silverside	0	0	5	0	2	0	7	0
Ambloplites rupestris (Rafinesque) Rock bass	16	0	30	7	23	0	69	7
Lepomis cyanellus Rafinesque Green sunfish	5	0	56	0	26	1	87	1
Lepomis macrochirus Rafinesque Bluegill	7	0	4	0	44	1	55	1
Lepomis megalotis (Rafinesque) Longear sunfish	55	1	154	36	157	4	366	41
Micropterus dolomieui Lacepede Smallmouth bass	8	1	34	13	18	2	60	16
Micropterus punctulatus (Rafinesque) Spotted bass	0	0	4	0	18	0	22	0
Micropterus salmoides (Lacepede) Largemouth bass	0	0	8	0	21	0	29	0
Etheostoma blennioides Rafinesque Greenside darter	1	19	13	15	2	27	16	61
Etheostoma caeruleum Storer Rainbow darter	1	419	4	786	0	386	5	1591
Etheostoma euzonum (Hubbs and Black) Arkansas saddled darter	0	8	0	95	0	69	0	172
Etheostoma juliae Meek Yoke darter	0	908	0	1400	0	2076	0	4384

TABLE 35

QUALITATIVE AND QUANTITATIVE MONTHLY FISH DATA

FROM JANUARY 1974 THROUGH FEBRUARY 1975

SPECIES	NUMBER OF FISHES							
	Upstream Station 1 Ponca, Ark.		Midstream Station 2 Hasty, Ark.		Downstream Station 3 Rush, Ark.		Total	
	Pool	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle
Etheostoma punctulatum (Agassiz) Stippled darter	1	1	0	0	0	0	1	1
Etheostoma stigmaeum (Jordan) Speckled darter	0	1	0	0	0	0	0	1
Etheostoma zonale (Cope) Banded darter	0	36	3	21	0	250	3	307
Percina caprodes (Rafinesque) Logperch	2	0	1	2	0	2	3	4
Percina evides (Jordan and Copeland) Gilt darter	0	0	0	0	0	17	0	17
Cottus bairdi Girard Mottled sculpin	0	0	0	0	1	0	1	0
Cottus carolinae (Gill) Banded sculpin	2	66	4	92	5	21	11	179
TOTAL SPECIES	17	22	30	25	29	21	74	68
TOTAL INDIVIDUALS	284	1896	770	4524	619	3422	1673	9842

TABLE 36 PHYSICOCHEMICAL DATA

STATION	AIR TEMP °C		WATER TEMP °C		D.O. PPM.		pH		WATER VELOCITY (CM/SEC)
	Pool	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle	Riffle
Upstream Station 1 Ponca, Ark.									
Jan. 19, 1974	20.0	20.0	11.5	11.5	14.6	14.6	7.7	7.7	
Feb. 16, 1974	11.0	11.0	8.0	8.0	12.2	12.2	7.7	7.7	
Mar. 11, 1974	15.0	15.0	12.5	12.5	10.4	10.4	7.2	7.2	158.5
Apr. 6, 1974	16.0	16.0	11.6	11.6	10.8	10.8	7.5	7.5	104.8
May 23, 1974	27.0	27.0	21.0	21.0	9.6	9.6	7.4	7.4	150.8
June 17, 1974	23.0	23.0	20.0	20.0	9.5	9.6	7.4	7.4	126.5
July 17, 1974	29.0	29.0	28.5	28.5	7.6	8.0	7.4	7.4	57.2
Aug. 13, 1974		33.0		26.0		8.5		7.5	63.3
Sep. 14, 1974		29.0		19.0		9.5		7.3	125.7
Oct. 26, 1974	27.0	27.0	16.5	16.5	10.0	10.0	7.4	7.4	75.5
Nov. 23, 1974	10.0	10.0	10.0	10.0	11.8	11.8	7.5	7.5	171.7
Dec. 14, 1974	6.0	6.0	5.0	5.0	12.6	12.6	7.5	7.5	167.7
Jan. 24, 1975	11.0	11.0	5.0	5.0	12.6	12.6	7.5	7.5	99.3
Feb. 14, 1975	10.0	10.0	7.0	7.0	9.4	9.4	7.3	7.3	154.3

PHYSICOCHEMICAL DATA (CONTINUED)

STATION	AIR TEMP °C		WATER TEMP °C		D.O. PPM.		pH		WATER VELOCITY (CM/SEC)
	Pool	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle	Riffle
Midstream Station 2 Hasty, Ark.									
Jan. 19, 1974	12.0	12.0	10.5	10.5	13.7	13.7	7.7	7.7	
Feb. 16, 1974	4.0	3.0	6.0	6.0	10.3	10.3	7.7	7.7	89.3
Mar. 11, 1974	15.0	15.5	14.5	14.5	9.5	9.5	7.5	7.5	118.3
Apr. 6, 1974	14.0	14.0	10.0	11.0	10.2	10.6	7.6	7.5	107.8
May 23, 1974	19.0	19.0	20.0	20.0					82.3
June 17, 1974	22.0	18.0	18.5	18.5	8.3	8.4	7.5	7.5	119.1
July 17, 1974	19.5	28.5	26.0	27.0	7.5	7.6	7.5	7.6	51.0
Aug. 13, 1974	18.0	29.0	23.0	26.0	7.5	8.3	7.5	7.8	52.8
Sep. 14, 1974	11.5	16.0	17.5	17.5	8.0	8.4	7.6	7.5	49.3
Oct. 26, 1974	9.0	9.0	14.0	13.5	9.0	9.6	7.4	7.6	80.8
Nov. 23, 1974	7.0	7.0	11.0	11.0	10.8	11.2	7.5	7.4	71.8
Dec. 14, 1974	2.0	2.0	5.0	5.0	10.2	11.8	7.4	7.5	114.3
Jan. 24, 1975	10.0	10.0	5.0	5.0	12.1	11.8	7.5	7.4	115.3
Feb. 14, 1975	11.0	11.0	8.0	7.0	9.0	9.0	7.5	7.5	120.8

PHYSICOCHEMICAL DATA (CONTINUED)

STATION	AIR TEMP °C Pool	AIR TEMP °C Riffle	WATER TEMP °C Pool	WATER TEMP °C Riffle	D.O. PPM. Pool	D.O. PPM. Riffle	pH Pool	pH Riffle	WATER VELOCITY (CM/SEC) Riffle
Downstream Station 3 Rush, Ark.									
Jan. 18, 1974	20.5	20.5	10.9	10.9	15.6	15.5	7.7	7.7	
Feb. 15, 1974	5.0	5.0	9.0	8.6	11.9	11.2	7.7	7.7	1115.9
Mar. 10, 1974	22.0	23.0	14.2	16.0	10.2	9.6	7.8	7.8	128.0
Apr. 5, 1974	16.0	16.5	12.5	13.5	10.9	11.2	7.6	7.6	153.8
May 22, 1974	26.0	26.0	20.0	23.8	8.6	9.0	7.5	7.5	155.1
June 17, 1974	22.0	22.0	20.0	20.8	8.5	8.7	7.5	7.6	178.0
July 17, 1974	29.5	34.0	28.5	29.3	7.7	8.7	8.0	7.8	127.2
Aug. 13, 1974	28.0	28.0	25.0	26.0	7.5	7.5	7.6	7.5	102.8
Sep. 14, 1974	17.0	17.0	20.0	21.0	8.0	8.3	7.3	7.2	120.7
Oct. 26, 1974	20.0	20.0	15.0	15.0	9.2	9.6	7.6	7.6	125.3
Nov. 23, 1974	19.0	19.0	12.0	12.0	10.4	12.2	7.5	7.5	148.2
Dec. 14, 1974	12.0	12.0	6.0	6.0	11.9	12.2	7.5	7.5	148.2
Jan. 24, 1975	11.0	11.0	5.0	5.0	12.3	12.8	7.6	7.7	118.0
Feb. 14, 1975	16.0	16.0	8.0	8.0	12.2	12.6	7.5	7.5	166.0

Table 37. Smallmouth Bass Collections.

SMALLMOUTH BASS COLLECTIONS

Collection Stations

Date 1974	Rush	Hasty	Ponca	Total
Jan.	2	4	1	7
Feb.	2	0	0	2
Mar.	3	7	2	12
Apr. 6	1	8	1	10
Apr. 26	-	7	-	7
May 23	1	6	2	9
May 28	-	11	-	11
June	6	5	-	11
July	5	4	-	9
Aug.	1	5	1	7
Sept.	4	4	2	10
Oct.	5	5	2	12
Nov.	5	5	-	10
Dec.	5	5	1	11
Total	40	76	12	128

BOTTOM FAUNA DESCRIPTION

By: Paul D. Kittle, Research Assistant
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Introduction

In many aquatic habitats benthic macroinvertebrates play an important role in food chains which lead to products of interest to man or are essential for the orderly function of aquatic ecosystems. Benthic macroinvertebrates, then, are especially significant in the trophic structure of stream ecosystems (Koslucher and Minshall, (23)). Gaufin and Tarzwell (24) state that little reliance can be placed upon the occurrence of a particular species at a given location and that few definite statements can be made concerning the indicator values of specific aquatic animals; however, Gaufin and Tarzwell also assert that "...definite conclusions can be formulated as to the value of certain associations or populations of aquatic invertebrates for indicating the severity and extent of pollution and the degree of stream recovery."

Schmitz (25) reported the results of a study of the shallow-water benthic macroinvertebrates at seven stations along the Buffalo River and one station on the Little Buffalo River from May 22 through June 25, 1973. The purpose of the present report is to contribute further to our knowledge of the benthic macroinvertebrates of the Buffalo National River; the results of

a continuation of the 1973 study conducted on June 24 and 25, 1974, are reported here. Schmitz (26) has presented a preliminary report on the present investigation.

Acknowledgments

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Methods and Materials

The Buffalo National River and Little Buffalo River, Arkansas, were sampled for shallow-water benthic macroinvertebrates on June 24 and 25, 1974. Organisms were collected from eight sampling stations as described by Schmitz (25) and as shown in Figure 1.

Both a riffle and shallow pool habitat were sampled qualitatively at each station where possible. Qualitative sampling consisted of hand-picking organisms from submerged rocks and sticks, hand-netting flying adult forms (e.g. damselflies), and disturbing the substrate in front of a dip net so that dislodged organisms were carried into the net by the current. Numbers of individuals collected during qualitative sampling (Table A4) are recorded for reference purposes only. These numbers may be

indicative of availability in terms of collecting methods used, but they should not be interpreted as indices of relative abundance.

Quantitative sampling was conducted with a Surber square-foot bottom sampler, and sampling was limited to riffles, deep runs, or faster-flowing shorelines of pools. Six square-foot samples were taken at each station and the samples were subsequently pooled. Samples were taken by forcing the square-foot frame of the Surber sampler into the substrate so that the opening of the net faced upstream. The substrate within the frame was then disturbed by washing and stirring the rocks and gravel. The dislodged organisms were carried into the net by the current. The contents of the net were emptied into a white enamel pan and the organisms were separated from debris by hand-picking with forceps.

Small organisms were preserved in 70% ethyl alcohol and larger specimens (e.g. crayfishes and mussels) were preserved in 5% formalin. Samples were transported to the laboratory, sorted by stations and major taxonomic categories, and identified to the lowest taxon possible.

Results and Discussion

Results are reported on a station-by-station basis. Detailed descriptions of the stations are presented by Schmitz (25). Changes in the habitats of the sampling stations which

occurred during the 1973-1974 interim are discussed. Results of the 1974 qualitative samples are presented in Table 38 and Appendix A4. Quantitative (numerical) results for 1974 are presented in Table 2, Figure 37; quantitative results from 1973 also are presented in Figure 37.

BR-1—State Highway 21 Bridge, Boxley. It was discovered that extensive bulldozing activity had occurred in the 1973 sampling area during the preceding year; therefore, the station was moved downstream about 100 feet to an area where it appeared that no direct disturbance had occurred. The river was almost dry on June 25, and a very shallow, slow-flowing riffle was sampled. A long pool below this riffle was sampled qualitatively.

One of the least diverse faunas was found at BR-1; only 17 taxa were collected (Table 38; Appendix A4). Schmitz (25) reported a moderately diverse fauna for this site. The reduction in diversity from 1973 to 1974 may be due in large part to the bulldozing activity mentioned above. The following major groups were recorded:

Hirudinea	Coleoptera
Decapoda	Trichoptera
Ephemeroptera	Diptera
Odonata	Hydracarina
Plecoptera	Gastropoda

Two major taxa collected during the present study, Hirudinea and Hydracarina, were not recorded for this site during the 1973 survey, while three major groups, Oligochaeta, Isopoda, and Neuroptera

(=Megaloptera), recorded in the 1973 survey were not collected from this station during the present study. BR-1 was the only station from which Hirudinea, Bidessus sp. (Coleoptera), and trichopteran pupae were taken (Table38). As in the 1973 study (Schmitz, (25)), Ephemeroptera were dominant in terms of diversity and seven genera were recorded (Table 38).

Station 1 was a moderately productive site in quantitative (numerical) terms, 15.0 organisms/ft.^{2} being recorded (Table 39; Figure37). As in the 1973 survey (Schmitz, (25)), Ephemeroptera were dominant numerically and accounted for 67% of the total quantitative sample (Table 39).

BR-2—Confluence with Mill Creek, Pruitt. Sampling was conducted along a 50-yard stretch below the confluence of Mill Creek and the Buffalo River. The water level was lower than during the 1973 sampling period, and extensive beds of water willow, Justicia americana, were present.

BR-2 supported the most diverse fauna and 32 taxa were recorded (Table 38; Appendix A4). The fauna at this station was also one of the most diverse during the 1973 study (Schmitz, (25)). The following major groups were noted:

Oligochaeta	Coleoptera
Decapoda	Trichoptera
Ephemeroptera	Diptera
Odonata	Gastropoda
Plecoptera	Pelecypoda
Neuroptera	

Pelecypoda were not recorded during the 1973 survey. This station was the only site from which Rhithrogena sp. (Ephemeroptera), adult plecopterans, and adult trichopterans were collected (Table 38). Neurocordulia sp. and Gomphus sp. (Odonata), two taxa not recorded during the 1973 survey, were taken only from this station. In terms of diversity, Ephemeroptera were dominant and eight genera were collected; the Odonata were sub-dominant, six genera being recorded (Table 38).

Relative to other stations, BR-2 was a very productive station quantitatively and 20.6 organisms/ft.^{2} were recorded (Table 39; Figure 37). Numerically, Schmitz (25) reported that Ephemeroptera and Diptera were the two most common groups collected during the 1973 study. These two groups also were numerically dominant during 1974. Ephemeroptera and Diptera accounted for 48% and 25% of the total, respectively (Table 39).

BR-3—State Highway 7 Bridge, Jasper. This station is located on the Little Buffalo River, and the 1973 sampling area was located just upstream from the bridge. Bulldozing activity for the construction of a new bridge adjacent to the old bridge had completely altered the 1973 site; therefore, a new sampling site was chosen about 150 feet downstream from the present bridge. Slow-flowing shallow areas along the shore of a deep run were sampled.

Qualitatively, BR-3 supported a fauna low in variety of

organisms, and only 19 taxa were obtained at this site (Table 38; Appendix A4). Schmitz (25) reported that this sampling station supported one of the most diverse faunas during the 1973 survey. The change from a fauna of high diversity in 1973 to one of low diversity in 1974 may be due in part to the bulldozing activity mentioned above and in part to the fact that the new sampling area which had to be chosen contained fewer microhabitats for benthic macroinvertebrate utilization. Major groups of benthos recorded were as follows:

Turbellaria	Neuroptera
Oligochaeta	Coleoptera
Decapoda	Trichoptera
Ephemeroptera	Diptera
Odonata	Gastropoda
Plecoptera	Pelecypoda

Three major taxa collected during the present study, Turbellaria, Oligochaeta, and Pelecypoda, were not recorded from this site in 1973. Dugesia sp. (Turbellaria) and Anax sp. (Odonata), organisms not found in the 1973 study, were collected only from this station (Table 38). As in the previous survey (Schmitz, (25)), Tropisternus sp. (Coleoptera) was recorded only from BR-3 (Table 38). In terms of diversity, no major group was clearly dominant. The Ephemeroptera were represented by four taxa, and the Odonata, Coleoptera, and Trichoptera each had three taxa represented (Table 38). Schmitz (1973) reported that the Ephemeroptera were clearly dominant, being represented by 12 genera.

Schmitz (25) noted that BR-3 was the most productive station quantitatively. This station was only moderately productive during the present study, and 17.6 organisms/ft.^{2} were collected (Table 39; Figure 37). The reduction in quantity of organisms from 1973 to 1974 is probably due to a combination of bulldozing activity and the less desirable downstream sampling habitat selected. Co-dominant groups were the Ephemeroptera and Oligochaeta, accounting for 31% and 27% of the total, respectively (Table 39). Schmitz (25) reported that Ephemeroptera were clearly dominant quantitatively, accounting for 53% of the organisms. The shift in abundance of Ephemeroptera (decrease) and Oligochaeta (increase) from 1973 to 1974 may reflect the shift of sampling areas. The 1974 sampling habitat contained much more organic and sandy substrate than did the 1973 area; this organic and sandy habitat supported a substantial population of burrowing oligochaetes and such is not favored by most forms of ephemeropterans.

BR-4—Low-water Bridge, Hasty. Both quantitative and qualitative samples were collected from the shallow riffle area immediately downstream from the bridge. A pool and a backwater area just upstream from the bridge were qualitatively sampled. The water level was lower than during the 1973 sampling period, and some of the riffle area sampled during the 1973 survey was dry.

One of the most diverse faunas was found at BR-4, and 30

taxa were recorded (Table 38; Appendix A4). Schmitz (25) also recorded a diverse fauna from this site. The following major groups of benthic macroinvertebrates were represented:

Oligochaeta	Neuroptera
Amphipoda	Coleoptera
Decapoda	Trichoptera
Ephemeroptera	Diptera
Odonata	Gastropoda
Plecoptera	

Two major groups noted during the present study, Oligochaeta and Amphipoda, were not recorded from BR-4 in the 1973 study, while one major group, Pelecypoda, was not recorded from this station during the present study. Polycentropus sp. (Trichoptera) was only taken from BR-4 (Table 38). As Schmitz stated (25), Ephemeroptera were dominant in terms of diversity and eight genera were recorded (Table 38).

BR-4 and BR-5 were the two most productive stations during the present study, and 25.4 organisms/$ft.^2$ were enumerated from BR-4 (Table 39; Figure 37). Ephemeroptera were dominant numerically and accounted for 74% of the total quantitative sample (Table 39). Schmitz (25) reported that on June 15, 1973, Ephemeroptera were dominant while on June 24, 1973, Coleoptera were dominant and Ephemeroptera were sub-dominant.

BR-5—Gravel Bar and Launch Area, Gilbert. Sampling at this site was conducted at the riffle, deep run, and pool areas located at the upstream extremity of the gravel bar. Three quantitative

samples were taken in a shallow riffle area and three were taken along shore of a deep run. One of the riffle areas sampled during the 1973 investigation was dry during the present study.

A moderately diverse fauna was collected at this site and 23 taxa were recorded (Table 38; Appendix A4). The survey by Schmitz (25) reported that BR-5 supported the least diverse fauna of any station. Major groups of benthos recorded were as follows:

Oligochaeta	Coleoptera
Decapoda	Trichoptera
Ephemeroptera	Diptera
Odonata	Hydracarina
Plecoptera	Gastropoda
Neuroptera	Pelecypoda

Two major taxa observed during the present study, Oligochaeta and and Hydracarina, were not recorded for this site in the 1973 survey, while two major groups, Hirudinea and Isopoda, recorded in the 1973 survey were not noted at this station during the present study. Enochrus sp. and Helochares sp. (Coleoptera) were taken from only this station (Table 38). In terms of diversity, no major group was clearly dominant. The Ephemeroptera and Coleoptera were each represented by four taxa, and the Odonata and Trichoptera were each represented by three taxa (Table 38). Schmitz (25) reported that Ephemeroptera were represented by six taxa during the 1973 study.

Station 5 and Station 4 were the two most productive stations during the present study, and 25.5 organisms/ft.^{2} were collected

from BR-5 (Table 39; Figure 37). Ephemeroptera (43%) were dominant in numbers and Trichoptera (24%) and Diptera (20%) were sub-dominant (Table 39). Schmitz (25) reported that on June 24, 1973, Ephemeroptera were dominant and Diptera were sub-dominant.

<u>BR-6—State Highway 14 Bridge</u>. The water level was lower than during the 1973 survey, and quantitative sampling consisted of three samples taken along shore of a deep run and three samples from a deep, swift riffle area on the north side of the river. The lower water level during the present study permitted access to a greater variety of microhabitats than during the 1973 study.

This station supported a moderately diverse fauna and 20 taxa were recorded (Table 38; Appendix A4). Major groups of benthic macroinvertebrates recorded from this site were as follows:

Oligochaeta
Decapoda
Ephemeroptera
Odonata
Plecoptera
Neuroptera
Coleoptera
Trichoptera
Diptera
Gastropoda
Pelecypoda

Representatives of three major taxa recorded during the present study, Neuroptera (=Megaloptera), Gastropoda, and Pelecypoda, were not collected during the 1973 study. No organisms were unique to this station (Table 38). Schmitz (25) reported that Ephemeroptera were the most diverse group in 1973 and were represented by nine genera. During the present study, no group was clearly dominant and only four genera of Ephemeroptera were collected (Table 38).

BR-6 was one of the least productive sites and a density of only 11.1 organisms/ft.^{2} was observed (Table 39; Figure 37). Schmitz (25) reported that this station was the least productive of all locations. As was the case at several other stations, Ephemeroptera were the dominant organisms numerically, comprising 81% of the total quantitative sample (Table 39). Schmitz (25) reported that Ephemeroptera constituted 72% of the total standing crop on June 24, 1973.

BR-7—Buffalo Point. This station, the former Buffalo River State Park, is characterized by a long pool with no riffle area present at the sampling site. The small riffle area reported by Schmitz (25) was dry during the present investigation. The substrate at this site is quite monotonous (Schmitz, (25)). Quantitative sampling consisted of a longitudinal transect of six samples along a 30-yard stretch of shoreline.

Faunal diversity at BR-7 was among the lowest of any station, and only 18 taxa were recorded (Table 38; Appendix A4). Representatives of the following major groups were found:

Oligochaeta	Coleoptera
Amphipoda	Trichoptera
Ephemeroptera	Diptera
Plecoptera	Gastropoda

Two major taxa noted during the present study, Oligochaeta and Amphipoda, were not recorded from this site during the 1973 survey, while two major groups, Decapoda and Neuroptera (=Megaloptera),

were not collected from this station during the present study. The absence of Decapoda from qualitative samples during the present study may be due to sampling error, as suggested by Schmitz (26). BR-7 was the only station from which Potamanthus sp. (Ephemeroptera) and Hydrovatus sp. (Coleoptera) were recorded (Table 38). Ephemeroptera and Coleoptera were the most diverse orders, exhibiting six and five genera, respectively (Table 38). Schmitz (25) reported that these two groups also were the most diverse during the 1973 study.

Station 7 was the least productive of all sites in quantitative terms and only 9.9 organisms/ft.^{2} were enumerated (Table 39; Figure 37). Schmitz (25) reported that this site was among the poorest in productivity. As in the 1973 survey, Ephemeroptera were dominant in numbers and accounted for 74% of the total quantitative sample (Table 39).

BR-8—Clabber Creek Shoals, Rush. This sampling site had changed little since the 1973 survey. Quantitative sampling consisted of a longitudinal transect of three samples and a horizontal transect of three samples in the exposed riffle area just below the confluence of Clabber Creek. The pool just above the riffle area was qualitatively sampled.

A moderately diverse benthic macroinvertebrate community was found at Station 8, and 24 taxa were collected (Table 38; Appendix A4). Schmitz (25) also reported a moderately diverse

fauna from this site. Major groups of benthos recorded were:

Oligochaeta	Trichoptera
Ephemeroptera	Diptera
Odonata	Hydracarina
Plecoptera	Gastropoda
Neuroptera	Pelecypoda
Coleoptera	

Two major groups collected during the present study, Oligochaeta and Hydracarina, were not recorded at BR-8 during the 1973 study, and one major group, Decapoda, was not collected during the present investigation. Schmitz (26) suggested that the absence of Decapoda may be due to sampling error. BR-8 was the only station from which Paraleptophlebia sp. (Ephemeroptera) was recorded (Table 38). Ephemeroptera were the most diverse group and six genera were recorded (Table 38). Four genera of Odonata and three taxa each of Trichoptera and Diptera also were collected (Table 38). The Ephemeroptera also were the most diverse group in the survey of the previous year (Schmitz, (25)).

This station supported a moderate standing crop of 16.2 organisms/ft.^{2} (Table 39; Figure 37). This site was the second most productive area during the 1973 survey (Schmitz, (25)). The Ephemeroptera and Trichoptera were dominant numerically, accounting for 41% and 39% of the total, respectively (Table 39). Schmitz (25) reported that Ephemeroptera were clearly dominant and Trichoptera were a relatively minor group.

General Observations and Comments. The Ephemeroptera were

the most diverse group at most stations during the 1973 survey, while Coleoptera and Trichoptera were occasionally sub-dominant (Schmitz, (25)). As noted by Schmitz (26), Ephemeroptera also presented the greatest diversity during the 1974 survey. Other groups which demonstrated considerable diversity during the present study included Odonata, Coleoptera, Trichoptera, and Diptera. BR-2, BR-3, and BR-4 exhibited the most diverse faunas in 1973 (Schmitz, (25)), while BR-2 and BR-4 supported the most diverse benthic communities during the present survey. The reduction in diversity at BR-3 from 1973-1974 may be due to the bulldozing activity and change in sampling area discussed above.

Although Coleoptera were dominant numerically at BR-4 during the 1973 survey, Ephemeroptera were dominant at all other stations and Diptera were sometimes a sub-dominant group (Schmitz, (25)). During the present study, Ephemeroptera were dominant at all stations except BR-3 and BR-8, where Oligochaeta and Trichoptera were co-dominant, respectively. Numerically sub-dominant groups in 1974 included Diptera, Oligochaeta, and Trichoptera. As noted by Schmitz (26), the great majority of ephemeropteran nymphs taken were early instars and "...therefore, the standing crop biomass contributed by Ephemeroptera could not be interpreted to be as great as that contributed by certain other groups characterized by lower densities and diversity..." Figure 37 demonstrates that, in general, the relative abundance of standing crops at the

various stations from 1973-1974 remained somewhat constant.

Schmitz (25) reported that the Buffalo River supported an extremely low standing crop of benthic macroinvertebrates during the 1973 study period. Although Figure 37 demonstrates that standing crops during the present study were considerably higher than in 1973, these numbers still indicate a relatively low standing crop during the sampling period. As mentioned by Schmitz (26), the 1973 sampling dates immediately followed the scouring effects of flooding and fluctuating water levels, while the present sampling period occurred at least two weeks after significant rainfall. Whether this difference in flooding accounts for the observed differences in standing crops from 1973-1974 is not known.

Thirteen new taxa were taken in 1974 which were not recorded in 1973; however, most benthic forms recorded in 1974 were also collected in 1973 (Schmitz, (26)). Thus, it appears that the short-term summer surveys have served their purposes, and if more extensive knowledge of the benthic fauna is needed, more intensive work throughout the year should be conducted (Schmitz, (26)).

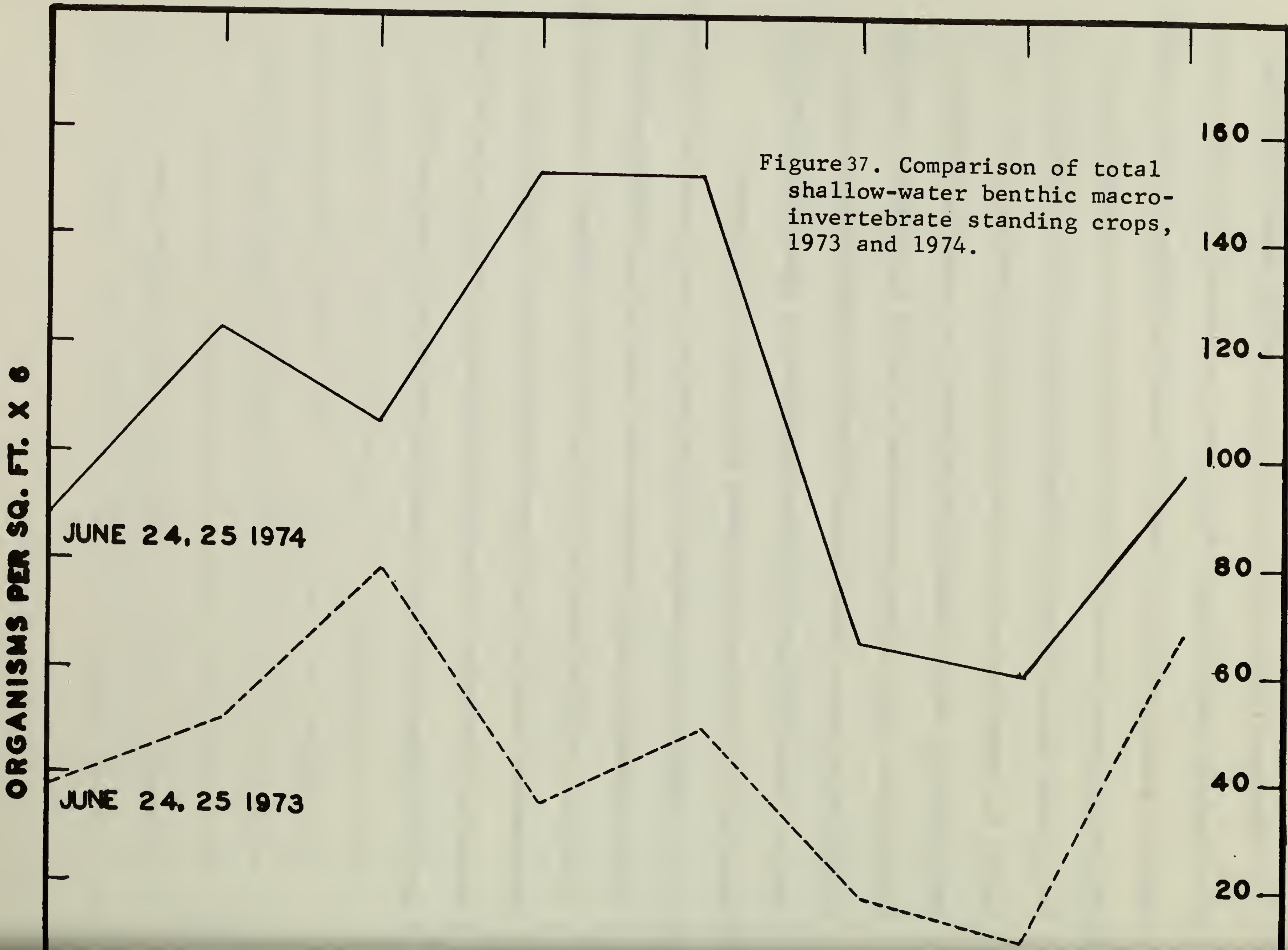

Figure 37. Comparison of total shallow-water benthic macro-invertebrate standing crops, 1973 and 1974.

	BR-1	BR-2	BR-3	BR-4	BR-5	BR-6	BR-7	BR-8
TURBELLARIA								
***Dugesia sp.			X					
OLIGOCHAETA		X	X	X	X	X	X**	X**
HIRUDINEA	X							
AMPHIPODA								
*Hyalella azteca				X			X	
DECAPODA								
Orconectes sp.	X	X	X	X	X	X		
EPHEMEROPTERA								
Isonychia sp.		X		X	X	X	X	X
Baetis sp.	X	X	X	X	X**			
**Centroptilum sp.	X	X	X	X	X			X
Pseudocloeon sp.	X	X**		X**				X**
Heptagenia sp.	X			X			X**	
Rhithrogena sp.		X						
Stenonema sp.	X**	X	X	X	X	X	X	X
Paraleptophlebia sp.								X
Ephemerella sp.	X	X					X	
Tricorythodes sp.		X**		X		X		
Caenis sp.	X**		X**	X				
**Potamanthus sp.							X	
Ephoron sp.						X	X	X
unidentified adults		X			X			
ODONATA								
***Anax sp.			X					
*Gomphus sp. (adult)		X						
*Hagenius sp.				X		X		X**
*Macromia sp.		X		X	X			
*Neurocordulia sp. (adult)		X						

Table 38. Qualitative distribution of shallow-water benthic macroinvertebrates at selected sampling sites on the Buffalo National River, June 24 and 25, 1974.

	BR-1	BR-2	BR-3	BR-4	BR-5	BR-6	BR-7	BR-8
ODONATA (continued)								
<u>Hetaerina</u> sp. (nymph)					X	X		X
(adult)		X				X		
<u>Argia</u> sp. (adult)	X	X		X	X			X
*<u>Enallagma</u> sp. (nymph)			X					X
(adult)		X	X	X				
PLECOPTERA								
<u>Acroneuria</u> sp.		X				X**		X
<u>Neoperla</u> sp.		X**		X	X**		X**	
<u>Perlesta</u> sp.	X	X	X					
unidentified adults		X						
NEUROPTERA(=Megaloptera)								
**<u>Chaulioides</u> sp.				X	X			
<u>Corydalus</u> sp.		X	X**	X		X		X
COLEOPTERA								
*<u>Bidessus</u> sp.	X							
<u>Hydrovatus</u> sp.							X	
<u>Enochrus</u> sp.					X			
*<u>Helochares</u> sp.					X			
*<u>Hydrochus</u> sp.							X	X
<u>Tropisternus</u> sp.			X					
<u>Lutrochus</u> sp.		X		X	X**	X**	X	
<u>Psephenus</u> sp. (larva)	X	X	X					
(adult)	X	X		X				
*<u>Dubiraphia</u> sp.		X					X	
<u>Stenelmis</u> sp. (larva)		X	X**					X**
(adult)		X	X**			X	X	X
<u>Helichus</u> sp. (adult)				X	X	X		
TRICHOPTERA								
<u>Chimarra</u> sp.		X		X**	X**			

Table 38. (continued).

	BR-1	BR-2	BR-3	BR-4	BR-5	BR-6	BR-7	BR-8
TRICHOPTERA (continued)								
Psychomyiidae								
*unidentified larva				X		X		X
***_Polycentropus_ sp.				X				
Cheumatopsyche sp.	X	X	X	X	X	X	X**	X
Hydropsyche sp.		X	X	X**	X	X	X**	X**
unidentified larva		X	X					
unidentified pupa	X							
unidentified adult		X						
DIPTERA								
Chironomidae (larva)	X	X	X**	X	X**	X	X**	X
(pupa)	X**		X**	X**		X		
Simuliidae		X		X	X**	X		X**
*Tabanidae		X		X**				X**
*HYDRACARINA	X**				X			X**
GASTROPODA	X	X	X	X	X	X	X	X
PELECYPODA		X	X		X	X		X

Table 38. (continued).

* not recorded in 1973 survey
** taken only in quantitative samples
*** both of the above

	BR-1	BR-2	BR-3	BR-4	BR-5	BR-6	BR-7	BR-8
TURBELLARIA			0.3					
OLIGOCHAETA		0.5	4.8		1.2	0.7	0.3	0.7
DECAPODA		0.2	0.2					
EPHEMEROPTERA	10.0	9.8	5.5	18.8	11.0	9.0	7.3	6.7
PLECOPTERA		0.2			0.2	0.2	0.2	
ODONATA			0.3					0.2
NEUROPTERA		0.2	0.2	0.2	0.2			
COLEOPTERA		2.2	1.8	0.2	0.8	0.7	0.3	0.8
TRICHOPTERA	2.0	2.3	1.5	1.7	6.2	0.5	1.5	6.3
DIPTERA	2.8	5.2	1.7	4.5	5.2		0.3	0.8
HYDRACARINA	0.2							
GASTROPODA			1.3		0.7			
PELECYPODA								0.2
(TOTAL ORGANISMS/FT.^{2})	15.0	20.6	17.6	25.4	25.5	11.1	9.9	16.2

Table 39. Standing crops of major taxa represented during June 24-25, 1974, sampling period (organisms/ft.^{2}).

GENERAL CONCLUSIONS

(See each section for specific conclusions.)

An analysis of the results of water samples on the Buffalo National River to date indicates that, with one exception, the water quality in the river is good. The one exception is the possible fecal contamination present in the river as indicated by high fecal coliform concentrations. Human fecal contamination can be caused by many different factors including:

1. Direct body contact - recreational use of the river
2. Improper or inadequate sewage treatment facilities (including improper septic tank and pit toilet installations)
3. The absence of sanitary facilities in remote areas

The problem of high fecal bacteria is the concern of one phase of the research to be conducted during FY 76.

Because rain showers were experienced throughout the watershed prior to and during the 1973 study, it is likely that the heterogeneous pattern observed for these constituents is produced by these constituents entering the river in surface runoff. The homogeneous pattern observed during the 1974 study may simply indicate that the river is approaching base flow conditions with essentially no runoff component.

The trends of element concentrations in the water and bottom sediment along the river correspond with rock type changes and abundance of the rock types in the river valley and mineralization. Unique sediments from tributaries are quickly diluted by mainstream sediments. However, perhaps attention should be given to ensuring stabilization of ore and tailings piles in the old lead and zinc mining areas in order to minimize pollution of the Buffalo River sediments. Water composition is also affected by flow which has a seasonal fluctuation.

During low flow (August) the major element content of the water increases because of lack of dilution by rain. The trace element concentrations do not correlate with season. Suspended sediment element concentrations (measured during non-storm periods) are very low. Suspended sediment element concentration levels are generally less than those for the water, except in the case of Fe which is approximately 10 times more abundant in the suspended sediments than in the water. Because of the narrow concentration range and very low element concentrations in the water, relationships between the sediments and water are not easily defined. However, the sediments from the Buffalo River can possibly be treated as a rough indicator of long term river water quality.

After a seasonal qualitative analysis of the algae there are certain patterns which have been discovered. Most populations are substrate specific, for instance, those epiphytic genera which occur only in the spring and summer when vascular plants are growing in the river. These epiphytic populations, when they occur, are more or less consistent along the length of the river. Other patterns are formed by genera which are seasonal because their growth is stimulated by temperature and light. There are also algae which occur exclusively in riffle or pool habitats. With all of these kinds of restrictions present, the total aspect of the river appears quite complex.

The standing crop of benthic macroinvertebrates during the 1974 study was considerably higher than in 1973. The 1973 sampling dates followed the effects of flooding and fluctuating water levels, while the 1974 sampling period occurred at least two weeks after significant rainfall. No conclusions can be drawn from this one-shot study. The general observations and comments made on p. 163-165 are as adequate as the data permits.

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APPENDIX A

TABLE A1. Concentration of elements in bottom sediments. Mg in ppm.

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	563.0	750.0	500.0	623.0	444.0	469.0	337.0	674.0	612.0	552.4
2	375.0	313.0	470.0	435.0	264.0	393.0	312.0	424.0	600.0	398.4
3	476.0	313.0	405.0	426.0	469.0	564.0	524.0	524.0	537.0	470.9
4	525.0	294.0	388.0	624.0	417.0	410.0	312.0	399.0	337.0	411.8
5	363.0	313.0	250.0	291.0	173.0	187.0	287.0	286.0	237.0	265.2
6	613.0	563.0	936.0	488.0	704.0	298.0	787.0	886.0	350.0	625.0
7	500.0	608.0	625.0	353.0	379.0	144.0	474.0	336.0	375.0	421.6
8	888.0	205.0	1620.0	874.0	2738.0	444.0	687.0	1574.0	762.0	1088.0
R	0.0	250.0	2940.0	0.0	4275.0	4624.0	4374.0	3125.0	4062.0	3378.6
C	3650.0	300.0	5750.0	0.0	5875.0	6199.0	8749.0	8750.0	5937.0	5651.3
P	0.0	0.0	0.0	560.0	0.0	486.0	462.0	335.0	475.0	463.6
MEAN FOR RIVER BY DATE:	537.9	419.9	649.3	514.3	698.5	363.6	465.0	637.9	476.3	
MEAN FOR CREEKS BY DATE:	3650.0	275.0	4345.0	560.0	5075.0	3769.7	4528.3	4070.0	3491.3	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	0.9	1.7	1.3	0.0	0.1	0.1	1.0	1.3	0.7	0.9
2	0.1	1.5	0.9	0.0	0.4	4.8	0.8	1.0	1.6	1.4
3	0.5	1.5	1.4	0.0	0.7	0.9	2.0	1.0	0.5	1.1
4	0.3	1.3	0.7	0.0	2.8	0.1	0.5	1.3	0.2	0.9
5	0.3	0.0	0.9	0.0	0.1	1.4	1.3	1.0	0.1	0.7
6	0.6	1.7	0.9	0.0	0.4	2.3	0.8	1.8	0.7	1.1
7	0.6	0.5	1.3	0.0	0.4	0.5	1.0	0.8	1.0	0.8
8	2.2	5.0	3.3	0.0	7.7	1.4	0.8	9.5	0.7	3.8
R	0.0	34.0	19.6	0.0	15.2	17.2	18.5	35.5	24.1	23.4
C	1.8	6.3	4.6	0.0	6.0	3.3	5.0	8.0	0.7	4.5
P	0.0	0.0	0.0	3.5	0.0	7.4	1.3	4.3	1.2	3.5
MEAN FOR RIVER BY DATE:	0.7	1.9	1.3	0.0	1.6	1.4	1.0	2.2	0.7	
MEAN FOR CREEKS BY DATE:	1.8	20.1	12.1	3.5	10.6	9.3	8.3	15.9	8.7	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

TABLE A1 (CONTINUED). CONCENTRATION OF NI IN BOTTOM SEDIMENT SAMPLES (ppm).

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	15.0	20.0	17.0	23.0	18.0	16.0	16.0	21.0	19.0	18.3
2	6.0	6.0	11.0	15.0	10.0	17.0	9.0	9.0	17.0	11.1
3	13.0	11.0	17.0	15.0	16.0	25.0	16.0	19.0	20.0	16.9
4	9.0	6.0	13.0	15.0	9.0	13.0	9.0	14.0	12.0	11.1
5	9.0	9.0	9.0	13.0	8.0	9.0	9.0	11.0	12.0	9.9
6	6.0	4.0	9.0	8.0	11.0	9.0	6.0	9.0	11.0	8.1
7	6.0	6.0	9.0	6.0	7.0	10.0	11.0	6.0	11.0	8.0
8	6.0	2.0	9.0	11.0	14.0	9.0	11.0	9.0	12.0	9.2
R	0.0	5.0	6.0	0.0	12.0	11.0	11.0	9.0	11.0	9.3
C	6.0	5.0	6.0	0.0	11.0	10.0	19.0	36.0	8.0	12.6
P	0.0	0.0	0.0	22.0	0.0	22.0	14.0	19.0	6.0	16.6
MEAN FOR RIVER BY DATE:	8.8	8.0	11.8	13.3	11.6	13.5	10.9	12.3	14.3	
MEAN FOR CREEKS BY DATE:	6.0	5.0	6.0	22.0	11.5	14.3	14.7	21.3	8.3	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

TABLE A1 (CONTINUED). CONCENTRATION OF CR IN BOTTOM SEDIMENT SAMPLES (ppm).

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	7.0	23.0	18.0	14.0	12.0	26.0	15.0	18.0	17.0	16.7
2	3.0	3.0	12.0	14.0	11.0	29.0	7.0	10.0	12.0	11.2
3	9.0	10.0	13.0	17.0	17.0	30.0	10.0	15.0	16.0	15.2
4	5.0	5.0	3.0	11.0	11.0	17.0	10.0	8.0	10.0	8.9
5	6.0	12.0	12.0	10.0	10.0	15.0	7.0	10.0	9.0	10.1
6	3.0	10.0	10.0	8.0	10.0	14.0	7.0	18.0	7.0	9.7
7	5.0	13.0	6.0	7.0	10.0	11.0	5.0	2.0	6.0	7.2
8	5.0	6.0	7.0	9.0	8.0	8.0	7.0	5.0	5.0	6.7
R	0.0	5.0	3.0	0.0	5.0	7.0	2.0	10.0	4.0	5.1
C	7.0	4.0	7.0	0.0	4.0	4.0	2.0	28.0	3.0	7.4
P	0.0	0.0	0.0	15.0	0.0	16.0	10.0	8.0	12.0	12.2
MEAN FOR RIVER BY DATE:	5.4	10.3	10.1	11.3	11.1	18.8	8.5	10.8	10.3	
MEAN FOR CREEKS BY DATE:	7.0	4.5	5.0	15.0	4.5	9.0	4.7	15.3	6.3	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

TABLE A1 (CONTINUED). CONCENTRATION OF NA IN BOTTOM SEDIMENT SAMPLES (ppm).

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	9.0	2.0	136.0	4.0	29.0	12.0	16.0	5.0	15.0	25.3
2	2.0	2.0	127.0	3.0	5.0	26.0	4.0	6.0	11.0	20.7
3	2.0	18.0	227.0	5.0	16.0	23.0	5.0	9.0	21.0	36.2
4	2.0	59.0	49.0	2.0	15.0	12.0	8.0	6.0	4.0	17.4
5	23.0	2.0	2.0	2.0	4.0	9.0	3.0	6.0	12.0	7.0
6	2.0	2.0	9.0	2.0	7.0	11.0	8.0	6.0	4.0	5.7
7	2.0	2.0	45.0	2.0	5.0	8.0	11.0	6.0	4.0	9.4
8	2.0	2.0	5.0	2.0	15.0	4.0	25.0	1.0	8.0	7.1
R	0.0	2.0	45.0	0.0	18.0	12.0	24.0	5.0	14.0	17.1
C	20.0	2.0	36.0	0.0	30.0	19.0	30.0	61.0	19.0	27.1
P	0.0	0.0	0.0	2.0	0.0	12.0	11.0	6.0	10.0	8.2
MEAN FOR RIVER BY DATE:	5.5	11.1	75.0	2.8	12.0	13.1	10.0	5.6	9.9	
MEAN FOR CREEKS BY DATE:	20.0	2.0	40.5	2.0	24.0	14.3	21.7	24.0	14.3	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

TABLE A 7 (CONTINUED). CONCENTRATION OF CU IN BOTTOM SEDIMENT SAMPLES (ppm).

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	6.0	9.0	6.3	8.0	5.0	6.0	4.0	8.0	8.0	6.7
2	3.0	2.0	3.0	5.0	2.0	3.0	5.0	3.0	6.0	3.6
3	6.0	4.0	5.0	4.0	6.0	8.0	8.0	10.0	9.0	6.7
4	4.0	2.0	5.0	4.0	3.0	3.0	5.0	5.0	5.0	4.0
5	4.0	3.0	3.0	2.0	1.0	1.0	5.0	5.0	5.0	3.2
6	2.0	3.0	3.0	1.0	3.0	2.0	5.0	3.0	3.0	2.8
7	3.0	4.0	3.0	1.0	2.0	2.0	4.0	3.0	3.0	2.8
8	3.0	3.0	3.0	4.0	4.0	1.0	3.0	5.0	5.0	3.4
R	0.0	6.0	1.0	0.0	8.0	6.0	7.0	8.0	10.0	6.6
C	6.0	5.0	9.0	0.0	8.0	7.0	9.0	12.0	8.0	8.0
P	0.0	0.0	0.0	3.0	0.0	7.0	5.0	5.0	7.0	5.4
MEAN FOR RIVER BY DATE:	3.9	3.8	3.9	3.6	3.3	3.3	4.9	5.3	5.5	
MEAN FOR CREEKS BY DATE:	6.0	5.5	5.0	3.0	8.0	6.7	7.0	8.3	8.3	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

TABLE A1 (CONTINUED). CONCENTRATION OF CO IN BOTTOM SEDIMENT SAMPLES (ppm).

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	13.0	15.0	7.0	11.0	14.0	12.0	11.0	18.0	9.0	12.2
2	3.0	4.0	7.0	9.0	3.0	2.0	5.0	8.0	13.0	6.0
3	9.0	4.0	6.0	9.0	15.0	8.0	8.0	13.0	8.0	8.9
4	7.0	4.0	6.0	7.0	9.0	11.0	5.0	8.0	5.0	6.9
5	4.0	5.0	7.0	5.0	7.0	8.0	5.0	7.0	5.0	5.9
6	4.0	5.0	6.0	3.0	12.0	5.0	4.0	5.0	3.0	5.2
7	4.0	7.0	7.0	4.0	1.0	6.0	6.0	3.0	4.0	4.7
8	4.0	4.0	6.0	6.0	7.0	8.0	5.0	3.0	8.0	5.7
R	0.0	6.0	6.0	0.0	14.0	11.0	8.0	7.0	7.0	8.4
C	4.0	6.0	8.0	0.0	16.0	8.0	20.0	30.0	6.0	12.3
P	0.0	0.0	0.0	15.0	0.0	16.0	8.0	11.0	7.0	11.4
MEAN FOR RIVER BY DATE:	6.0	6.0	6.5	6.8	8.5	7.5	6.1	8.1	6.9	
MEAN FOR CREEKS BY DATE:	4.0	6.0	7.0	15.0	15.0	11.7	12.0	16.0	6.7	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

TABLE A1 (CONTINUED). CONCENTRATION OF FE IN BOTTOM SEDIMENT SAMPLES (ppm).

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	2.0	2.5	1.9	3.1	1.9	2.3	1.6	2.4	2.8	2.3
2	0.8	1.0	0.9	1.9	1.1	1.4	0.8	1.3	1.7	1.2
3	1.7	1.4	1.7	2.0	1.9	2.4	1.2	2.2	2.4	1.9
4	1.3	0.9	1.0	1.6	1.4	1.4	0.9	1.5	1.2	1.3
5	4.1	1.0	0.8	1.1	0.8	0.8	0.9	1.2	1.0	1.3
6	0.3	0.8	0.7	0.9	1.0	0.8	0.8	0.9	0.8	0.8
7	0.8	0.9	0.9	0.8	0.8	0.7	0.9	0.6	0.8	0.8
8	0.6	0.4	0.7	1.2	0.7	0.6	0.7	0.7	0.9	0.7
R	0.0	3.5	2.8	0.0	0.6	0.3	0.4	0.5	0.6	1.3
C	3.2	3.8	4.2	0.0	0.4	0.5	0.5	0.6	0.5	1.7
P	0.0	0.0	0.0	2.8	0.0	2.5	1.4	2.1	2.2	2.2
MEAN FOR RIVER BY DATE:	1.5	1.1	1.1	1.6	1.2	1.3	1.0	1.3	1.4	
MEAN FOR CREEKS BY DATE:	3.2	3.7	3.5	2.8	0.5	1.1	0.8	1.1	1.1	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

TABLE A1 (CONTINUED). CONCENTRATION OF MN IN BOTTOM SEDIMENT SAMPLES (ppm).

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	902.0	956.0	508.0	1137.0	682.0	704.0	925.0	1050.0	800.0	851.6
2	173.0	235.0	240.0	730.0	144.0	351.0	375.0	400.0	550.0	355.3
3	400.0	250.0	280.0	521.0	442.0	634.0	625.0	550.0	562.0	473.8
4	278.0	180.0	400.0	676.0	303.0	325.0	450.0	325.0	312.0	361.0
5	292.0	288.0	152.0	333.0	179.0	161.0	600.0	250.0	250.0	278.3
6	162.0	185.0	190.0	214.0	303.0	128.0	375.0	200.0	125.0	209.1
7	162.0	342.0	305.0	144.0	162.0	115.0	250.0	200.0	150.0	203.3
8	128.0	132.0	162.0	521.0	276.0	106.0	175.0	125.0	100.0	191.7
R	0.0	240.0	187.0	0.0	564.0	236.0	200.0	150.0	500.0	296.7
C	277.0	227.0	335.0	0.0	259.0	394.0	1825.0	600.0	312.0	528.6
P	0.0	0.0	0.0	1154.0	0.0	848.0	1250.0	450.0	437.0	827.8
MEAN FOR RIVER BY DATE:	312.1	321.0	279.6	534.5	311.4	315.5	471.9	387.5	356.1	
MEAN FOR CREEKS BY DATE:	277.0	233.5	261.0	1154.0	411.5	492.7	1091.7	400.0	416.3	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

TABLE A1 (CONTINUED). CONCENTRATION OF ZN IN BOTTOM SEDIMENT SAMPLES (ppm).

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	70.0	58.0	58.0	61.0	49.0	53.0	37.0	90.0	88.0	62.7
2	42.0	58.0	78.0	52.0	25.0	53.0	39.0	90.0	245.0	75.8
3	79.0	58.0	78.0	68.0	61.0	83.0	98.0	90.0	145.0	84.4
4	48.0	49.0	58.0	53.0	58.0	48.0	34.0	115.0	195.0	73.1
5	42.0	54.0	33.0	35.0	21.0	32.0	36.0	340.0	108.0	77.9
6	67.0	113.0	104.0	69.0	76.0	72.0	73.0	515.0	108.0	133.0
7	92.0	79.0	87.0	53.0	65.0	54.0	61.0	340.0	170.0	111.2
8	343.0	430.0	350.0	172.0	183.0	92.0	98.0	1415.0	195.0	364.2
R	0.0	4050.0	2180.0	0.0	1871.0	1681.0	2148.0	4990.0	170.0	2441.4
C	136.0	500.0	365.0	0.0	500.0	166.0	273.0	640.0	2500.0	635.0
P	0.0	0.0	0.0	1457.0	0.0	1923.0	53.0	1140.0	375.0	989.6
MEAN FOR RIVER BY DATE:	97.9	112.4	105.8	70.4	67.3	60.9	59.5	374.4	156.8	
MEAN FOR CREEKS BY DATE:	136.0	2275.0	1272.5	1457.0	1185.5	1256.7	824.7	2256.7	1015.0	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

TABLE A.1 (CONTINUED). CONCENTRATION OF K IN BOTTOM SEDIMENT SAMPLES (ppm).

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	186.0	299.0	184.0	266.0	199.0	203.0	187.0	182.0	230.0	215.1
2	163.0	77.0	99.0	184.0	81.0	130.0	72.0	22.0	360.0	132.0
3	278.0	119.0	164.0	199.0	220.0	287.0	167.0	50.0	237.0	191.2
4	204.0	74.0	124.0	169.0	150.0	132.0	92.0	50.0	120.0	123.9
5	198.0	104.0	92.0	111.0	82.0	85.0	112.0	35.0	115.0	103.8
6	158.0	99.0	74.0	91.0	144.0	95.0	107.0	2.0	90.0	95.6
7	154.0	124.0	97.0	74.0	109.0	85.0	117.0	4.0	75.0	93.2
8	138.0	59.0	87.0	166.0	112.0	74.0	92.0	7.0	110.0	93.9
R	0.0	42.0	39.0	0.0	156.0	75.0	100.0	8.0	95.0	73.6
C	160.0	47.0	87.0	0.0	142.0	11.0	130.0	52.0	88.0	89.6
P	0.0	0.0	0.0	224.0	0.0	153.0	132.0	5.0	155.0	133.8
MEAN FOR RIVER BY DATE:	184.9	119.4	115.1	157.5	137.1	136.4	118.3	44.0	167.1	
MEAN FOR CREEKS BY DATE:	160.0	44.5	63.0	224.0	149.0	79.7	120.7	21.7	112.7	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	605.0	970.0	640.0	585.0	1800.0	212.0	126.0	260.0	280.0	608.7
2	1302.0	3380.0	13700.0	2010.0	331.0	1128.0	1496.0	380.0	3750.0	3053.0
3	740.0	1460.0	2060.0	2105.0	745.0	1443.0	20746.0	1870.0	3750.0	3879.9
4	990.0	887.0	3040.0	3035.0	1035.0	888.0	3246.0	395.0	870.0	1598.4
5	928.0	1670.0	843.0	1135.0	610.0	393.0	11121.0	1870.0	900.0	2163.3
6	990.0	2300.0	2290.0	1443.0	2805.0	442.0	1746.0	2995.0	1000.0	1779.0
7	740.0	2725.0	3400.0	785.0	701.0	274.0	2996.0	285.0	900.0	1422.9
8	2115.0	7300.0	6800.0	3485.0	13637.0	1193.0	2746.0	6495.0	2120.0	5099.0
R	0.0	9600.0	7080.0	0.0	14507.0	16069.0	12750.0	16745.0	11125.0	12553.7
C	18230.0	2500.0	33400.0	0.0	23781.0	33238.0	*******	*******	18375.0	51345.6
P	0.0	0.0	0.0	16235.0	0.0	10679.0	9496.0	9995.0	3000.0	9881.0

	B	C	D	E	F	G	H	I	J
MEAN FOR RIVER BY DATE:	1051.3	2586.5	4096.6	1822.9	2708.0	746.6	5527.9	1818.8	1696.3
MEAN FOR CREEKS BY DATE:	18230.0	6050.0	20240.0	16235.0	19144.0	19995.3	46997.3	63078.3	10833.3

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

(continued)

TABLE A7 (CONTINUED). CONCENTRATION OF PB IN BOTTOM SEDIMENT SAMPLES (ppm).

STATIONS	B	C	D	E	F	G	H	I	J	MEAN FOR STATIONS
1	11.0	15.0	9.0	0.2	15.0	13.0	7.5	22.5	13.7	11.9
2	4.0	7.0	8.0	2.0	11.0	13.0	17.5	25.0	30.0	13.1
3	9.0	10.0	17.0	18.0	13.0	13.0	25.0	17.5	17.5	15.6
4	7.0	5.0	11.0	0.1	17.0	28.0	12.5	15.0	5.0	11.2
5	7.0	6.0	5.0	0.3	7.0	5.0	7.5	5.0	5.0	5.3
6	8.0	6.0	4.0	0.6	6.0	13.0	15.0	15.0	15.0	9.2
7	7.0	8.0	6.0	1.0	5.0	2.0	17.5	7.5	12.5	7.4
8	6.0	6.0	6.0	2.0	10.0	17.0	17.5	7.5	7.5	8.8
R	0.0	7.6	4.6	11.0	0.0	9.0	12.5	17.5	27.5	12.8
C	10.0	14.0	14.0	10.0	0.0	28.0	20.0	40.0	5.0	17.6
P	0.0	0.0	0.0	0.0	357.0	75.0	12.5	57.5	28.0	106.0
MEAN FOR RIVER BY DATE:	7.4	7.9	8.3	3.0	10.5	13.0	15.0	14.4	13.3	
MEAN FOR CREEKS BY DATE:	10.0	10.8	9.3	10.5	357.0	37.3	15.0	38.3	20.2	

1 - 8 REPRESENTS STATIONS SHOWN IN FIGURE 17.

R - RUSH CREEK, C - CLABBER CREEK, P - PONCA CREEK.

0.0 - INDICATES NO SAMPLES COLLECTED.

B-J Collection dates: B (5/22-23/73), C (6/9/73, D (6/24/73), E (3/12/74), F (5/22/74), G (6/17/74, H (8/21/74, I (12/21/74), J (3/26/75).

Table A2. Analyses of suspended sediment in parts per billion ($\mu g/lt$ of H_2O).

Element	Collection Date*	Station 1 Boxley	Station 2 Pruitt	Station 3 Jasper	Station 4 Hasty	Station 5 Gilbert	Station 6 Highway 14 Bridge	Station 7 Buffalo River State Park	Station 8 Rush	Clabber Creek	Rush Creek	Ponca Creek
Na	F	82	8	11	10	9	8	8	(9)[a]	16.8	5.5	-
	G	55	62	3	8	73	2	14	57	20	43	11
	H	-	6	6	12	10	11.4	10	2	4	6	(8)[b]
	I	10	10	10	10	10	10	10	10	-	-	10
	J	3.3	10	2.8	5	11.4	3.4	4.8	6.4	20.8	6	5
K	F	39.5	1.0	0.3	0.3	0.2	0.2	0.2	(1.2)[a]	10.1	0.2	-
	G	8	8	5	5	5	4	3	4.2	3	3	3
	H	-	0.8	5.4	4	0.4	13.4	0.4	0.4	3	3	(2)[b]
	I	1	1	1	1	1	1	1	1	-	-	1
	J	6.7	5	1.8	1.8	5.2	3.6	2.6	6.2	6.5	0.7	0.8
Ca	F	32	16	22	27	40	31	35	(45)[a]	41	29	-
	G	20	16	13	13	30	21	23	29	15	10	12
	H	-	33	75	38	39	73	79	35	29	28	(34)[b]
	I	11	18	18	22	20	20	25	38	-	-	25
	J	9	9	19	15	26	41	40	35	17	15	30
Mg	F	8	3	3	6	7	6	7	(9)[a]	14	6	-
	G	9	14	8	8	15	9	10	-	4	3	2
	H	-	4	6	5	4	4	5	4	12	5	(3)[b]
	I	4	3	3	4	3	3	3	7	-	-	2
	J	6	4	5	6	7	10	9	12	15	8	3
Fc	F	133	106	65	137	147	108	108	(80)[a]	11	33	-
	G	242	328	194	227	338	165	178	143	15	15	76
	H	-	64	83	65	57	20	65	34	14	25	(105)[b]
	I	96	75	81	91	80	49	66	70	-	-	75
	J	104	105	137	119	161	218	190	175	17	27	125

(continued)

Table A2 (cont'd). Analyses of suspended sediment in parts per billion (µg/lt. of H_2O).

Element	Collection Date*	Station 1 Boxley	Station 2 Pruitt	Station 3 Jasper	Station 4 Hasty	Station 5 Gilbert	Station 6 Highway 14 Bridge	Station 7 Buffalo River State Park	Station 8 Rush	Clabber Creek	Rush Creek	Ponca Creek
Co	F	2.0	0.7	0.9	0.8	0.7	0.7	0.7	(0.7)[a]	0.7	0.6	-
	G	1.0	1.0	0.7	0.7	0.7	0.5	0.4	0.45	0.4	0.4	0.4
	H	-	-	-	-	-	-	-	-	-	-	-
	I	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	-	-	0.3
	J	-	-	-	-	-	-	-	-	-	-	-
Cr	F	1	0.3	0.4	0.4	0.4	0.3	0.3	(0.4)[a]	0.3	0.2	-
	G	0.6	0.6	00.4	0.4	0.9	0.5	0.3	0.3	0.3	0.3	0.3
	H	-	-	-	-	-	-	-	-	-	-	-
	I	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-	-	0.5
	J	-	-	-	-	-	-	-	-	-	-	-
Ni	F	3	1	1.3	1.2	1.6	1	1	(4)[a]	1	0.7	-
	G	4	2	1.0	1.0	1.0	1	0.65	0.7	0.6	0.6	1
	H	-	-	-	-	-	-	-	-	-	-	-
	I	1	0.3	0.3	1	0.3	0.3	0.3	0.3	-	-	0.3
	J	-	-	-	-	-	-	-	-	-	-	-
Cu	F	12	4	5	5	4	4	4	(4)[a]	4	3	-
	G	-	-	-	-	-	-	-	-	-	-	-
	H	-	-	-	-	-	-	-	-	-	-	-
	I	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-	-	0.5
	J	-	-	-	-	-	-	-	-	-	-	-
Zn	F	29	1	1	0.5	1	0.3	1	(1)[a]	1	5	-
	G	11	2	2	2	1	1	1	1	0.3	1	3
	H	-	0.3	1	0.3	0.3	2	0.3	7	0.3	1	(2)[b]
	I	1	1	1	1	1	1	1	1	-	-	1
	J	1	1	1	1	1	2	1	2	2	2	3

(continued)

Table A2 (cont'd). Analyses of suspended sediment in parts per billion (µg/lt. of H_2O).

Element	Collection Date *	Station 1 Boxley	Station 2 Pruitt	Station 3 Jasper	Station 4 Hasty	Station 5 Gilbert	Station 6 Highway 14 Bridge	Station 7 Buffalo River State Park	Station 8 Rush	Clabber Creek	Rush Creek	Ponca Creek
Cd	F	0.4	0.4	0.5	0.4	0.4	0.4	0.4	(0.4)[a]	0.4	0.4	-
	G	0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.13	0.1	0.13	0.1
	H	-	-	-	-	-	-	-	-	-	-	-
	I	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	-	-	0.15
	J	-	-	-	-	-	-	-	-	-	-	-
Pb	F	2.5	35	1	1	3.4	1	1	(1)[a]	1	0.6	-
	G	1	1	0.8	0.8	0.9	0.6	0.6	0.5	2.3	0.5	0.5
	H	-	-	-	-	-	-	-	-	-	-	-
	I	3	3	2.4	3	3	3	3	3	-	-	1
	J	-	-	-	-	-	-	-	-	-	-	-
Mn	F	3.8	4.3	2.8	6.1	7.0	5.1	6.2	(6.8)[a]	1.2	2.1	-
	G	5.8	7.6	4.3	5.2	11.6	7.1	11.9	6.7	0.8	1.1	1.9
	H	-	29[c]	25[c]	26[c]	5[c]	7[c]	9[c]	7[c]	2[c]	1.5[c]	(11)[b]
	I	2.9	3.9	1.5	1.2	1.5	1.0	1.0	1.8	-	-	0.7
	J	3.3	2.2	3.0	4.2	5.5	8.5	6.4	8.1	1.0	1.6	2.6
Li	F	-	-	-	-	-	-	-	-	-	-	-
	G	-	-	-	-	-	-	-	-	-	-	-
	H	-	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	(0.1)[b]
	I	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	-	0.1
	J	0.1	0.1	0.1	0.1	0.1	0.05	0.1	0.1	0.02	0.04	0.13

(continued)

Table A2 (cont'd). Analyses of suspended sediment in parts per billion (μg/lt. of H_2O).

Element	Collection Date*	Station 1 Boxley	Station 2 Pruitt	Station 3 Jasper	Station 4 Hasty	Station 5 Gilbert	Station 6 Highway 14 Bridge	Station 7 Buffalo River State Park	Station 8 Rush	Clabber Creek	Rush Creek	Ponca Creek
Sr	F	-	-	-	-	-	-	-	-	-	-	-
	G	-	-	-	-	-	-	-	-	-	-	-
	H	-	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	(0.7)[b]
	I	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	-	-	0.4
	J	0.7	0.6	0.8	0.4	0.5	0.4	0.4	0.4	0.7	0.2	0.4

*F-5/21-22/74, G-6/17/74, H-8/19-21/74, I-12/20-21/74, J-3/6/75.

[a] From Buffalo River near Rush, 0.2 mile above station 8.

[b] From Buffalo River 50 yards below Ponca Creek.

[c] These analyses are by the standard method of filtration through a 0.45μm filter and analysis of the retained material. These values were checked by analyzing filtered (0.45μm) and unfiltered samples of water which were acidified with 8 drops of conc. HCl/100 ml. Acidification was after filtration in the case of the filtered samples. By the difference (Δ = Mn conc. in unfiltered samples minus Mn conc. in filtered sample), the concentration of suspended material was obtained. Standard values (S) are compared below to the Δ values for stations 2 to 8 and three creeks.

	Mn (ppb)									
	St 2	St 3	St 4	St 5	St 6	St 7	St 8	Clabber Creek	Rush Creek	Ponca Creek
S	29	25	26	5	7	9	7	2	1.5	11
Δ	83	31	37	4	7	7	18	0	0	0

Element	Collection Date*	Station 1 Boxley	Station 2 Pruitt	Station 3 Jasper	Station 4 Hasty	Station 5 Gilbert	Station 6 Highway 14 Bridge	Station 7 Buffalo River State Park	Station 8 Rush	Clabber Creek	Rush Creek	Ponca Creek
Na	E	860	1,240	950	1,030	1,170	1,340	1,590	(1,260)[a]	-	-	1,120
	F	976	1,105	1,312	1,242	1,242	1,272	1,262	(1,412)[a]	1,045	1,132	-
	G	973	1,110	1,390	1,250	1,250	1,290	1,300	1,283	1,070	1,370	1,280
	H	-	2,200	3,500	2,120	1,830	1,940	2,020	2,000	1,200	1,030	(2,250)[b]
	I	934	1,160	1,340	1,310	1,250	1,320	1,320	1,370	-	-	1,290
	J	1,084	1,297	1,582	1,457	1,452	1,471	1,490	1,466	1,214	1,249	1,495
K	E	666	796		822	802	923	940	(842)[a]	-	-	947
	F	797	853	860	872	847	866	872	(916)[a]	900	853	-
	G	775	880	895	918	872	850	865	865	820	805	1,022
	H	-	1,170	1,240	1,080	1,040	1,070	1,060	1,080	1,020	966	(1,340)[b]
	I	527	660	665	696	635	625	635	707	-	-	792
	J	639	715	700	690	690	690	715	725	705	700	824
Ca	E	5,100	21,800	15,800	18,800	23,700	24,300	25,800	(29,500)[a]	-	-	28,500
	F	8,000	20,000	24,500	23,500	38,500	40,700	41,200	(41,500)[a]	52,500	52,500	-
	G	11,500	37,000	37,000	44,000	49,000	49,000	49,500	47,700	62,000	63,000	56,500
	H	-	39,000	42,000	42,000	39,000	37,000	37,000	36,000	38,000	48,000	(38,000)[b]
	I	7,300	22,400	25,000	28,300	30,000	31,900	31,300	33,700	-	-	41,700
	J	5,300	22,000	20,000	27,000	33,000	32,000	32,000	33,000	54,000	45,000	42,000
Mg	E	862	1,460	1,300	1,312	1,425	1,750	1,850	(2,930)[a]	-	-	2,300
	F	1,120	1,950	1,700	2,000	2,800	3,300	3,250	(3,350)[a]	28,000	9.600	-
	G	1,040	2,250	1,740	2,250	2,700	3,250	3,400	5,600	27,100	10,500	3,550
	H	-	4,200	2,900	3,850	3,530	3,950	3,950	4,720	25 600	8,400	(3,550)[b]
	I	1,035	1,970	1,670	2,090	2,250	2,550	2,550	8,870	-	-	3,220
	J	919	1,900	1,485	1,884	2,112	2,560	2,547	4,623	25,600	7,100	2,800

(continued)

Table A3 (cont'd). Water analyses in parts per billion

Element	Collection Date*	Station 1 Boxley	Station 2 Pruitt	Station 3 Jasper	Station 4 Hasty	Station 5 Gilbert	Station 6 Highway 14 Bridge	Station 7 Buffalo River State Park	Station 8 Rush	Clabber Creek	Rush Creek	Ponca Creek
Fe	E	41	40	31	36	30	30	27	(16)[a]	-	-	12
	F	21	11.5	11.5	9.5	8.0	10.0	10.0	(10.5)[a]	11.0	7.0	7.0
	G	13	7.0	8.0	3.0	4.0	6.0	3.0	6.0	5.0	6.0	5.0
	H	-	16.0	8.0	5.0	6.0	4.0	4.0	3.0	1	1	(14.0)[b]
	I	19.3	14.4	6.8	6.8	4.9	3.0	4.0	4.4	-	-	0.2
	J	11.3	27.7	3.9	2.8	1.1	54.3	1	1	1.2	5.5	4.1
Co	E	-	-	-	-	-	-	-	-	-	-	-
	F	2	2	2	2	2	6	2	(2)[a]	2	2	-
	G	2	2	2	2	2.0	2	2	2	2	2	2.0
	H	-	2.0	5.0	5.0	4.0	4.0	5.0	5	4.0	5.0	(6.0)[b]
	I	4.0	2.7	2.6	2.2	2.9	2.8	4.7	3.1	-	-	3.6
	J	9.3	3.6	3.4	3.6	3.6	2.9	2.8	4.3	4.8	5.7	3.4
Cr	E	-	-	-	-	-	-	-	-	-	-	-
	F	2	2	2	2	2	2	3	(2)[a]	2	2	-
	G	2	2	2	2	2	2	2	2	2	2	2
	H	-	3	1	1	2	1	2	1	1	1	(1)[b]
	I	2	2	2	2	2	2	2	2	-	-	4.0
	J	2	2	2	2	2	2	2	2	2	2	2
Ni	E	-	-	-	-	-	-	-	-	-	-	-
	F	4.0	3.0	3.0	6.0	2	2	2	(2)[a]	5.0	2	-
	G	8.0	7.0	7.0	6.0	4.0	6.0	6.0	6.0	5.0	6.0	8.0
	H	-	3.0	2.0	2	4.0	2.0	3.0	2.0	2	2.0	(3.0)[b]
	I	1	1.5	3.3	2.1	2.1	3.6	3.9	1.5	-	0	1
	J	2.2	0.1	0.7	2.2	2.2	1.0	1.6	4.3	1.9	4.3	2.8

(continued)

Table A3 (cont'd). Water analyses in parts per billion

Element	Collection Date*	Station 1 Boxley	Station 2 Pruitt	Station 3 Jasper	Station 4 Hasty	Station 5 Gilbert	Station 6 Highway 14 Bridge	Station 7 Buffalo River State Park	Station 8 Rush	Clabber Creek	Rush Creek	Ponca Creek
Cu	E	8.0	4.0	5.0	4.0	6.0	4.0	5.0	(3.0)[a]	-	-	3
	F	1	1	1	1	12	14	1	(1)[a]	1	1	-
	G	1	1	2.0	1	1.0	1.0	2.0	1.0	2.0	2.0	1
	H	-	1	1	1	1	1	1	1	1	1	(1)[b]
	I	0.3	1.8	1.6	2.4	1.2	1.3	2.4	3.0	-	-	2.4
	J	3.5	0.8	1.0	2.0	1.2	1.2	1.3	1.0	0.6	1.2	1.1
Zn	E	6.0	4.0	12	4	15	5	6	(7)[a]	-	-	10
	F	4	4	163	12	20	20	6	(9)[a]	2	24.5	-
	G	12.0	102	90	20	103	41	26	15	46	67	106
	H	-	2	8	1	87	2	7	3	3	36	(3)[b]
	I	10.4	15	74	101	147	39	43	348	-	-	36
	J	4.6	0.9	0.3	2.0	1.0	1.0	1.0	1.6	4.6	35.6	7.4
Cd	E	2.0	1.0	1.0	2.0	1.0	1.0	1.0	(2)[a]	-	-	2
	F	1.7	1.2	1.2	1	1.0	1.0	2.0	(1)[a]	2	2	-
	G	1	1	1	1	1	1	1	1	1	1	1
	H	-	1	1	1	1	1	1	1	1	1	(1)[b]
	I	1.0	0.7	0.7	0.5	0.4	1	1.0	.1	-	-	0.4
	J	0.3	0.3	.5	0.3	0.2	.5	1.6	0.8	0.5	0.8	0.4
Pb	E	10	4.0	5.0	2.0	10	3.0	1.0	(2)[a]	-	-	4.0
	F	6.5	5.5	7.5	8.5	5.2	15.5	7.7	6.0	4.2	3.2	-
	G	3.0	8.0	8.0	7.0	3.0	3.0	4.0	4.0	1.0	10	8.0
	H	-	3.0	7.0	3.0	3.0	3.0	3.0	3.0	2	2.0	(1.0)[b]
	I	0.8	4.0	2.5	8.1	2.8	2	9.5	5.1	-	-	7.5
	J	5.3	8.8	7.9	9.4	0.3	5.3	2.1	8.5	2.7	12.0	3.2

(continued)

Table A3 (cont'd). Water analyses in parts per billion

Element	Collection Date*	Station 1 Boxley	Station 2 Pruitt	Station 3 Jasper	Station 4 Hasty	Station 5 Gilbert	Station 6 Highway 14 Bridge	Station 7 Buffalo River State Park	Station 8 Rush	Clabber Creek	Rush Creek	Ponca Creek
Mn	E	7.0	7.5	7.0	10.5	3.0	5.0	9.0	(7)[a]	-	-	3
	F	3.5	10.5	8.5	5.0	9.7	5.0	6.7	(11)[a]	9.0	2.0	-
	G	3.4	11.2	8.9	9.4	8.7	5.2	5.0	6.1	7.0	4.0	6.0
	H	-	7.1	8.2	4.2	17.0	7.3	8.2	7.3	5.7	4.2	(29.3)[b]
	I	3.1	8.0	10.2	9.2	6.2	5.6	8.4	5.7	-	-	4.5
	J	4.5	11.9	7.6	7.3	6.7	6.3	6.7	10.2	9.3	6.4	6.7
Li	E	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-
	G	-	-	-	-	-	-	-	-	-	-	-
	H	-	2	2	2	1	1	1	1	1	1	(2)[b]
	I	2	2	2	2	2	2	2	2	-	-	2
	J	2	2	2	2	2	2	2	1	3	2	2
Sr	E	-	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-	-
	G	-	-	-	-	-	-	-	-	-	-	-
	H	-	54	63	47	47	51	60	44	32	35	(48)[b]
	I	7	22	33	22	29	29	33	33	-	-	18
	J	10	22	29	32	38	45	35	38	35	29	32

* The letters in this column correspond to the following collection dates: E - 3/12/74, F - 5/21-22/74, G - 6/17/74, H - 8/19-21/74, I - 12/20-21/74, J - 3/6/75.

[a] From Buffalo River near Rush Creek, 0.2 mile above station 8.

[b] From Buffalo River 50 yards below Ponca Creek.

Appendix A4

BR-1 25 June 1974 Qualitative Samples

HIRUDINEA 1

DECAPODA

Astacidae
Orconectes sp. 6

EPHEMEROPTERA

Baetidae
Baetis sp. 1
Pseudocloeon sp. 4

Heptageniidae
Heptagenia sp. 1

Ephemerellidae
Ephemerella sp. 1

ODONATA

Coenagrionidae
Argia sp. (adult) 1

PLECOPTERA

Perlidae
Perlesta sp. 1

COLEOPTERA

Dytiscidae
Bidessus sp. (adult) 1

Psephenidae
Psephenus sp. (larva) 3
(adult) 3

TRICHOPTERA

unidentified pupa 1

Hydropsychidae
Cheumatopsyche sp. 2

DIPTERA

Chironomidae 1

GASTROPODA 1

Appendix A4—continued

BR-2 25 June 1974 Qualitative Samples

OLIGOCHAETA 1

DECAPODA

Astacidae
Orconectes sp. 13

EPHEMEROPTERA

unidentified adults 12

Siphlonuridae
Isonychia sp. 35

Baetidae
Baetis sp. 1

Heptageniidae
Rhithrogena sp. 1
Stenonema sp. 31

Ephemerellidae
Ephemerella sp. 2

ODONATA

Gomphidae
Gomphus sp. (adult) 1

Macromiidae
Macromia sp. (nymph) 3

Libellulidae
Neurocordulia sp. (adult) 1

Calopterygidae
Hetaerina sp. (adult) 1

Coenagrionidae
Argia sp. (adult) 3
Enallagma sp. (adult) 1

PLECOPTERA

Perlidae
unidentified adult 1
Acroneuria sp. 1
Perlesta sp. 1

NEUROPTERA

Corydalidae
Corydalus sp. (larva) 4

COLEOPTERA

Limnichidae
Lutrochus sp. (adult) 5

Psephenidae
Psephenus sp. (larva) 3
(adult) 3

Elmidae
Dubiraphia sp. (adult) 3
Stenelmis sp. (larva) 3
(adult) 8

TRICHOPTERA

unidentified larva 1

unidentified adult 1

Philopotamidae
Chimarra sp. 1

Hydropsychidae
Cheumatopsyche sp. 14
Hydropsyche sp. 3

Appendix A4—continued

BR-2—continued 25 June 1974 Qualitative Samples

DIPTERA

Chironomidae 18

Simuliidae 5

Tabanidae 1

GASTROPODA 13

PELECYPODA 2

Appendix A4 -continued

BR-3 25 June 1974 Qualitative Samples

OLIGOCHAETA 1

DECAPODA

Astacidae
Orconectes sp. 11

EPHEMEROPTERA

Baetidae
Baetis sp. 2

Heptageniidae
Stenonema sp. 9

ODONATA

Coenagrionidae
Enallagma sp. (nymph) 1
(adult) 3

PLECOPTERA

Perlidae
Perlesta sp. 1

COLEOPTERA

Hydrophilidae
Tropisternus sp. (adult) 1

Psephenidae
Psephenus sp. (larva) 4

TRICHOPTERA

unidentified larva 1

Hydropsychidae
Cheumatopsyche sp. 2
Hydropsyche sp. 1

GASTROPODA 10

PELECYPODA 1

Appendix A4 -continued

BR-4 25 June 1974 Qualitative Samples

OLIGOCHAETA 1

AMPHIPODA

Talitridae
Hyalella azteca 2

DECAPODA

Astacidae
Orconectes sp. 4

EPHEMEROPTERA

Siphlonuridae
Isonychia sp. 4

Baetidae
Baetis sp. 3

Heptageniidae
Heptagenia sp. 1
Stenonema sp. 8

Tricorythidae
Tricorythodes sp. 1

Caenidae
Caenis sp. 1

ODONATA

Gomphidae
Hagenius sp. (nymph) 3

Macromiidae
Macromia sp. (nymph) 3

Coenagrionidae
Argia sp. (adult) 1
Enallagma sp. (adult) 1

PLECOPTERA

Perlidae
Neoperla sp. 1

NEUROPTERA

Corydalidae
Corydalus sp. (larva) 1

COLEOPTERA

Dryopidae
Helichus sp. (adult) 1

Limnichidae
Lutrochus sp. (adult) 9

Psephenidae
Psephenus sp. (adult) 6

TRICHOPTERA

Psychomyiidae
unidentified larva 1

Hydropsychidae
Cheumatopsyche sp. 2

DIPTERA

Chironomidae 2

Simuliidae 2

GASTROPODA 11

Appendix A4—continued

BR-5 24 June 1974 Qualitative Samples

OLIGOCHAETA 1

DECAPODA

Astacidae
Orconectes sp. 16

EPHEMEROPTERA

unidentified adults 2

Siphlonuridae
Isonychia sp. 6

Heptageniidae
Stenonema sp. 1

ODONATA

Macromiidae
Macromia sp. (nymph) 2

Calopterygidae
Hetaerina sp. (nymph) 3

Coenagrionidae
Argia sp. (adult) 1

COLEOPTERA

Hydrophilidae
Enochrus sp. (adult) 1
Helochares sp. (adult) 1

Dryopidae
Helichus sp. (adult) 1

TRICHOPTERA

Hydropsychidae
Cheumatopsyche sp. 1
Hydropsyche sp. 1

HYDRACARINA 1

GASTROPODA 23

PELECYPODA 7

Appendix A4—continued

BR-6 25 June 1974 Qualitative Samples

OLIGOCHAETA 2

DECAPODA

Astacidae
Orconectes sp. 6

EPHEMEROPTERA

Siphlonuridae
Isonychia sp. 12

Heptageniidae
Stenonema sp. 3

Tricorythidae
Tricorythodes sp. 1

Polymitarcidae
Ephoron sp. 1

ODONATA

Gomphidae
Hagenius sp. (nymph) 2

Calopterygidae
Hetaerina sp. (nymph) 2
(adult) 1

NEUROPTERA

Corydalidae
Corydalus sp. (larva) 5

COLEOPTERA

Dryopidae
Helichus sp. (adult) 1

Elmidae
Stenelmis sp. (adult) 2

TRICHOPTERA

Psychomyiidae
unidentified larva 1

Hydropsychidae
Cheumatopsyche sp. 6
Hydropsyche sp. 1

DIPTERA

Chironomidae (larva) 2
(pupa) 1

Simuliidae 1

GASTROPODA 24

PELECYPODA 1

Appendix A4—continued

BR-7 24 June 1974 Qualitative Samples

AMPHIPODA

Talitridae
Hyalella azteca 1

EPHEMEROPTERA

Siphlonuridae
Isonychia sp. 1

Heptageniidae
Stenonema sp. 3

Ephemerellidae
Ephemerella sp. 5

Polymitarcidae
Ephoron sp. 1

COLEOPTERA

Dytiscidae
Hydrovatus sp. (adult) 1

Hydrophilidae
Hydrochus sp. (adult) 1

Limnichidae
Lutrochus sp. (adult) 1

Elmidae
Dubiraphia sp. (adult) 3
Stenelmis sp. (adult) 27

GASTROPODA 8

Appendix A4—continued

BR-8 24 June 1974 Qualitative Samples

EPHEMEROPTERA

Siphlonuridae
Isonychia sp. 14

Heptageniidae
Stenonema sp. 16

Leptophlebiidae
Paraleptophlebia sp. 1

Polymitarcidae
Ephoron sp. 3

ODONATA

Calopterygidae
Hetaerina sp. (nymph) 4

Coenagrionidae
Argia sp. (adult) 1
Enallagma sp. (nymph) 1

PLECOPTERA

Perlidae
Acroneuria sp. 1

NEUROPTERA

Corydalidae
Corydalus sp. (larva) 1

COLEOPTERA

Hydrophilidae
Hydrochus sp. (adult) 1

Elmidae
Stenelmis sp. (adult) 1

TRICHOPTERA

Psychomyiidae
unidentified larva 1

Hydropsychidae
Cheumatopsyche sp. 9

DIPTERA

Chironomidae 18

GASTROPODA 18

PELECYPODA 2

Appendix A5

BR-1 25 June 1974 Quantitative Sample 6 sq. ft.

EPHEMEROPTERA

Baetidae
Baetis sp. 4
Centroptilum sp. 27
Pseudocloeon sp. 1

Heptageniidae
Heptagenia sp. 1
Stenonema sp. 26

Caenidae
Caenis sp. 1

TRICHOPTERA

Hydropsychidae
Cheumatopsyche sp. 12

DIPTERA

Chironomidae (larva) 13
(pupa) 4

HYDRACARINA 1

SUMMARY

EPHEMEROPTERA 60

TRICHOPTERA 12

DIPTERA 17

HYDRACARINA 1

TOTAL ORGANISMS 90

Appendix A5 -continued

BR-2 25 June 1974 Quantitative Sample 6 sq. ft.

OLIGOCHAETA 3

DECAPODA

Astacidae
Orconectes sp. 1

EPHEMEROPTERA

Siphlonuridae
Isonychia sp. 1

Baetidae
Centroptilum sp. 10
Pseudocloeon sp. 16

Heptageniidae
Stenonema sp. 31

Tricorythidae
Tricorythodes sp. 1

PLECOPTERA

Perlidae
Neoperla sp. 1

NEUROPTERA

Corydalidae
Corydalus sp. (larva) 1

COLEOPTERA

Psephenidae
Psephenus sp. (larva) 2
(adult) 7

Elmidae
Stenelmis sp. (adult) 4

TRICHOPTERA

Hydropsychidae
Cheumatopsyche sp. 11
Hydropsyche sp. 3

DIPTERA

Chironomidae 25

Simuliidae 6

SUMMARY

OLIGOCHAETA 3

DECAPODA 1

EPHEMEROPTERA 59

PLECOPTERA 1

NEUROPTERA 1

COLEOPTERA 13

TRICHOPTERA 14

DIPTERA 31

TOTAL ORGANISMS 123

Appendix A5—continued

BR-3 25 June 1974 Quantitative Sample 6 sq. ft.

TURBELLARIA

Planariidae
Dugesia sp. 2

OLIGOCHAETA 29

DECAPODA

Astacidae
Orconectes sp. 1

EPHEMEROPTERA

Baetidae
Baetis sp. 2
Centroptilum sp. 16

Heptageniidae
Stenonema sp. 9

Caenidae
Caenis sp. 6

ODONATA

Aeshnidae
Anax sp. (nymph) 1

Gomphidae (nymph) 1

NEUROPTERA

Corydalidae
Corydalus sp. (larva) 1

COLEOPTERA

Psephenidae
Psephenus sp. (larva) 4

COLEOPTERA (continued)

Elmidae
Stenelmis sp. (larva) 2
(adult) 5

TRICHOPTERA

Hydropsychidae
Cheumatopsyche sp. 8
Hydropsyche sp. 1

DIPTERA

Chironomidae (larva) 9
(pupa) 1

GASTROPODA 8

SUMMARY

TURBELLARIA 2

OLIGOCHAETA 29

DECAPODA 1

EPHEMEROPTERA 33

ODONATA 2

NEUROPTERA 1

COLEOPTERA 11

TRICHOPTERA 9

DIPTERA 10

GASTROPODA 8

TOTAL ORGANISMS 106

Appendix A5-continued

BR-4 25 June 1974 Quantitative Sample 6 sq. ft.

EPHEMEROPTERA

Siphlonuridae
Isonychia sp. 45

Baetidae
Centroptilum sp. 5
Pseudocloeon sp. 7

Heptageniidae
Heptagenia sp. 1
Stenonema sp. 55

NEUROPTERA

Corydalidae
Chaulioides sp. (larva) 1

COLEOPTERA

Psephenidae
Psephenus sp. (adult) 1

TRICHOPTERA

Philopotamidae
Chimarra sp. 1

Psychomyiidae
Polycentropus sp. 1

Hydropsychidae
Cheumatopsyche sp. 7
Hydropsyche sp. 1

DIPTERA

Chironomidae (larva) 21
(pupa) 1

Simuliidae 4

Tabanidae 1

SUMMARY

EPHEMEROPTERA 113

NEUROPTERA 1

COLEOPTERA 1

TRICHOPTERA 10

DIPTERA 27

TOTAL ORGANISMS 152

Appendix A5--continued

BR-5 24 June 1974 Quantitative Sample 6 sq. ft.

OLIGOCHAETA 7

EPHEMEROPTERA

Siphlonuridae
Isonychia sp. 13

Baetidae
Baetis sp. 3
Centroptilum sp. 7
Pseudocloeon sp. 3

Heptageniidae
Stenonema sp. 40

PLECOPTERA

Perlidae
Neoperla sp. 1

NEUROPTERA

Corydalidae
Chaulioides sp. (larva) 1

COLEOPTERA

Limnichidae
Lutrochus sp. (adult) 3

Dryopidae
Helichus sp. (adult) 2

TRICHOPTERA

Philopotamidae
Chimarra sp. 2

Hydropsychidae
Cheumatopsyche sp. 7
Hydropsyche sp. 28

DIPTERA

Chironomidae 3

Simuliidae 28

GASTROPODA 4

SUMMARY

OLIGOCHAETA 7

EPHEMEROPTERA 66

PLECOPTERA 1

NEUROPTERA 1

COLEOPTERA 5

TRICHOPTERA 37

DIPTERA 31

GASTROPODA 4

TOTAL ORGANISMS 152

Appendix A5—continued

BR-6 24 June 1974 Quantitative Sample 6 sq. ft.

OLIGOCHAETA 4

EPHEMEROPTERA

Siphlonuridae
Isonychia sp. 15

Heptageniidae
Stenonema sp. 38

Tricorythidae
Tricorythodes sp. 1

PLECOPTERA

Perlidae
Acroneuria sp. 1

COLEOPTERA

Limnichidae
Lutrochus sp. (adult) 1

Elmidae
Stenelmis sp. (adult) 3

TRICHOPTERA

Hydropsychidae
Cheumatopsyche sp. 3

SUMMARY

OLIGOCHAETA 4

EPHEMEROPTERA 54

PLECOPTERA 1

COLEOPTERA 4

TRICHOPTERA 3

TOTAL ORGANISMS 66

Appendix A5—continued

BR-7 24 June 1974 Quantitative Sample 6 sq. ft.

OLIGOCHAETA 2

EPHEMEROPTERA

Heptageniidae
Heptagenia sp. 3
Stenonema sp. 27

Potamanthidae
Potamanthus sp. 1

Polymitarcidae
Ephoron sp. 13

PLECOPTERA

Perlidae
Neoperla sp. 1

COLEOPTERA

Elmidae
Stenelmis sp. (adult) 2

TRICHOPTERA

Hydropsychidae
Cheumatopsyche sp. 2
Hydropsyche sp. 7

DIPTERA

Chironomidae 2

SUMMARY

OLIGOCHAETA 2

EPHEMEROPTERA 44

PLECOPTERA 1

COLEOPTERA 2

TRICHOPTERA 9

DIPTERA 2

TOTAL ORGANISMS 60

Appendix A5 -continued

BR-8 24 June 1974 Quantitative Sample 6 sq. ft.

OLIGOCHAETA 4

EPHEMEROPTERA

Siphlonuridae
Isonychia sp. 8

Baetidae
Centroptilum sp. 1
Pseudocloeon sp. 1

Heptageniidae
Stenonema sp. 27

Polymitarcidae
Ephoron sp. 3

ODONATA

Gomphidae
Hagenius sp. 1

COLEOPTERA

Elmidae
Stenelmis sp. (larva) 1
(adult) 4

TRICHOPTERA

Psychomyiidae
unidentified larva 1

Hydropsychidae
Cheumatopsyche sp. 19
Hydropsyche sp. 18

DIPTERA

Chironomidae 2

Simuliidae 2

Tabanidae 1

HYDRACARINA 3

PELECYPODA 1

SUMMARY

OLIGOCHAETA 4

EPHEMEROPTERA 40

ODONATA 1

COLEOPTERA 5

TRICHOPTERA 38

DIPTERA 5

HYDRACARINA 3

PELECYPODA 1

TOTAL ORGANISMS 97

APPENDIX B

WATER QUALITY-INTENSE USE PERIOD (OWRT Funding)

R. W. Raible
University of Arkansas Graduate Institute of Technology

The following report contains information which is part of the preliminary Reconnaissance Water Quality Survey of the Buffalo National River by the Arkansas Water Resources Research Center. The readings were taken at a time when peak visitor use occurs and at a site where maximum changes in the water quality of the river would be expected. This information is intended as part of a baseline study to provide for future comparisons as river use increases.

Data were taken for seven consecutive days beginning on Saturday, July 7, 1973 at a station located fifty yards upstream from the outfall of the Buffalo River National Park sewage treatment plant as indicated on the map in Figure B1. Readings of dissolved oxygen, water temperature, specific conductance, and pH were taken at four-hour intervals and are plotted in Figures B2, B3, B4, and B5. Frequent measurements were also taken below the sewage plant for the Buffalo River National Park, but these readings were not significantly different from the ones above the plant. The ammonia level was measured frequently; however, with the exception of one reading of 0.1 part per million taken on the morning of July 11, the ammonia level was undetectable since it was less than 0.05 part per million which was the limit of sensitivity of the method of measurement involved. Sulfide, chloride, sulfate, turbidity, total hardness, alkalinity, nitrates, nitrites, nitrogen, and orthophosphates were measured, on a spot check basis, and the

results of these tests are tabulated in Table B1.

At the time of the study, July 7 through July 13, some construction was taking place around the sewage treatment plant at the Buffalo River National Park. The soil at the sewer outfall was sandy and had accumulated a quantity of ammonia from the outfall. In the course of the construction, some of this soil was dislodged and rolled into the stream. This soil disturbance accounted for the one detectable ammonia reading of 0.1 part per million which was obtained on July 11 a few hours after the soil fell into the stream. However, as soon as the turbidity caused by the soil disturbance cleared, the ammonia level dropped back to the previous undetectable level.

At the midpoint of the investigation, on July 11, a canoe trip was made from the Buffalo River National Park to Rush and samples were taken along this length of the river. The data obtained on the canoe trip were not significantly different from the noon and 4:00 P.M. readings taken on July 11 at the Buffalo River National Park. During the study no significant changes in the water quality occurred that could not be attributed to natural causes. For example, the increase in turbidity which was measured at 8:00 P.M. on July 9 followed a shower which occurred about 5:00 P.M. By the morning of Tuesday, July 10, turbidity had returned to its previous level.

Due to the diurnal pattern of shallow streams, all the data recorded on one day at a specific time should correspond well to the data taken at the same time on another day, i.e. 4:00 P.M. readings taken on July 7 through 13 should be in close agreement, assuming there were no perturbing activities such as a rain shower. Thus, the data for each time of the seven-day period were averaged and the averaged data are plotted in Figures B6, B7, B8, and B9. These graphs indicate the normal diurnal pattern for a shallow stream such

as the Buffalo River.

During the investigation considerable flow existed and flushing action was good as indicated by the river level readings. It was noted that during the period of this study the water level of the stream dropped about 4 inches. Table B2 contains the river level at Gilbert, Arkansas, as indicated by the U.S. Weather Bureau's river gauge at the time of the study. It is anticipated that during dry summers the flushing action would be reduced since the river level would drop considerably below that observed during the test period, and under conditions of decreased rainfall the characteristics of the water would differ considerably from those obtained during the test period.

The park was operating at capacity during the period of these tests, and since the weather was favorable, large numbers of people were swimming each day. The occupancy figures are given in Table B3.

TABLE B1

MISCELLANEOUS READINGS

	12 Noon July 7	4 P.M. July 7	12 Noon July 8	4 P.M. July 8	8 A.M. July 9	12 Noon July 9	8 P.M. July 9	12 Midnight July 9	8 A.M. July 11	12 Noon July 11	8 P.M. July 12
Cloride		≈0							5 mg/1		
Sulfate		3 ppm	4 ppm		10 ppm	4 ppm					
Turbidity		2 JTU	10 JTU		2 JTU	2 JTU	10 JTU*	5 JTU			
Total Hardness ($CaCO_3$)	.	140 mg/1	140 mg/1								
Alkalinity (Total)				90 mg/1							150 mg/1
Nitrate Nitrogen				.05 mg/1							
Nitrates				undetectable						None	
Ammonia											
Orthophosphate									.1 ppm		

*Light shower at 5:20 P.M.

TABLE B2

RIVER DEPTH AT GILBERT, ARKANSAS
AT THE TIME THE DATA WERE TAKEN

Date	Depth
July 6	1.2 feet
July 8	1.2 feet
July 9	1.0 feet
July 10	1.0 feet
July 11	1.0 feet
July 12	1.0 feet
July 13	1.0 feet

reference — where gauge??

TABLE B3

OCCUPANCY OF BUFFALO RIVER NATIONAL PARK
DURING THE STUDY

	Campground	Cabins	Day Use	Total
July 6	445	52	420	917
July 7	464	57	680	1201
July 8	450	52	770	1272
July 9	472	56	410	938
July 10	461	55	385	901
July 11	453	61	425	939
July 12	420	59	430	909
July 13	438	58	375	871

FIGURE B1

MAP IN WHICH ARROW INDICATES THE STATION AT WHICH READINGS WERE TAKEN.

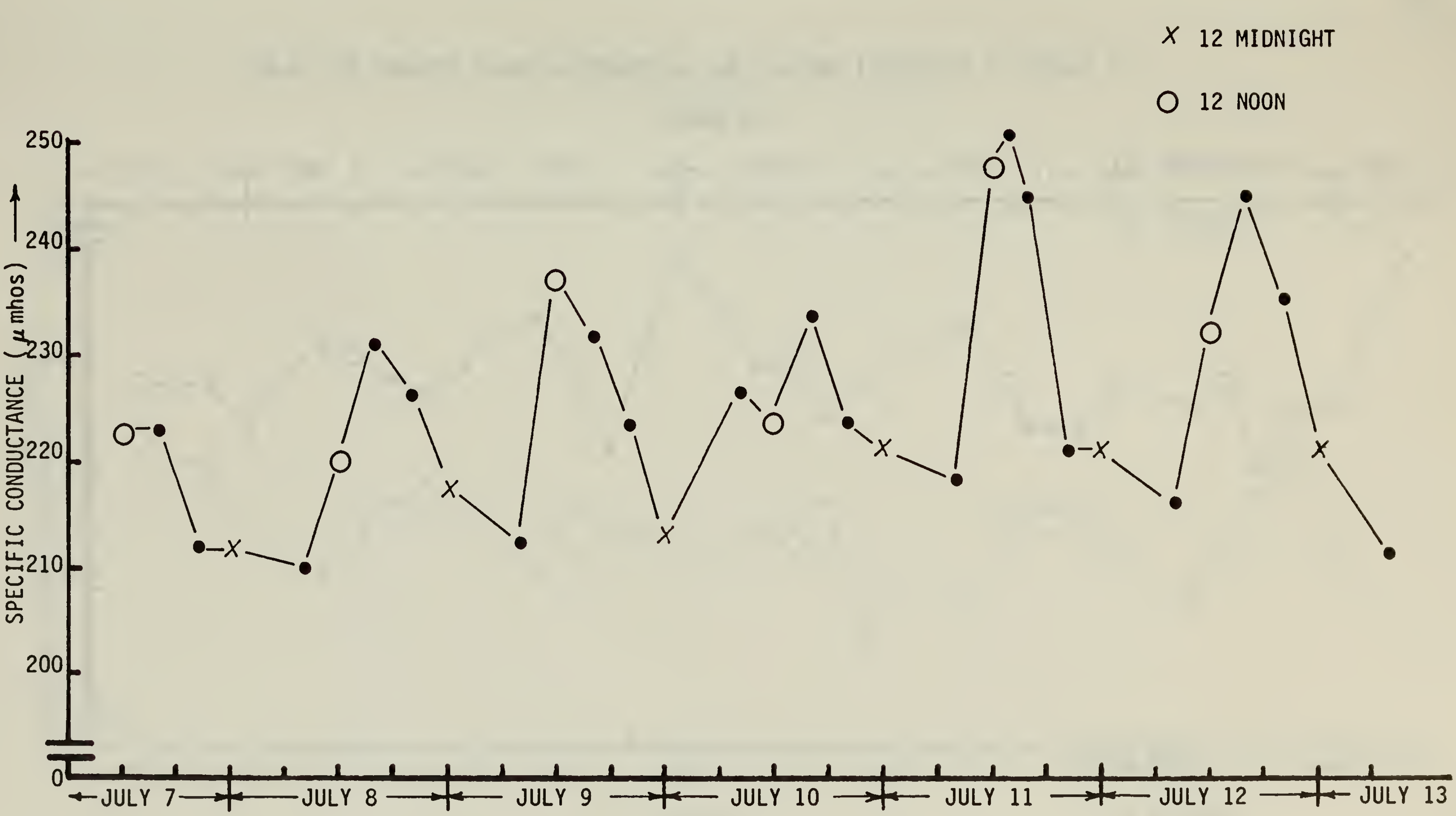

FIGURE B2

SPECIFIC CONDUCTANCE OF THE BUFFALO RIVER MEASURED AT THE STATION INDICATED IN FIGURE B1.

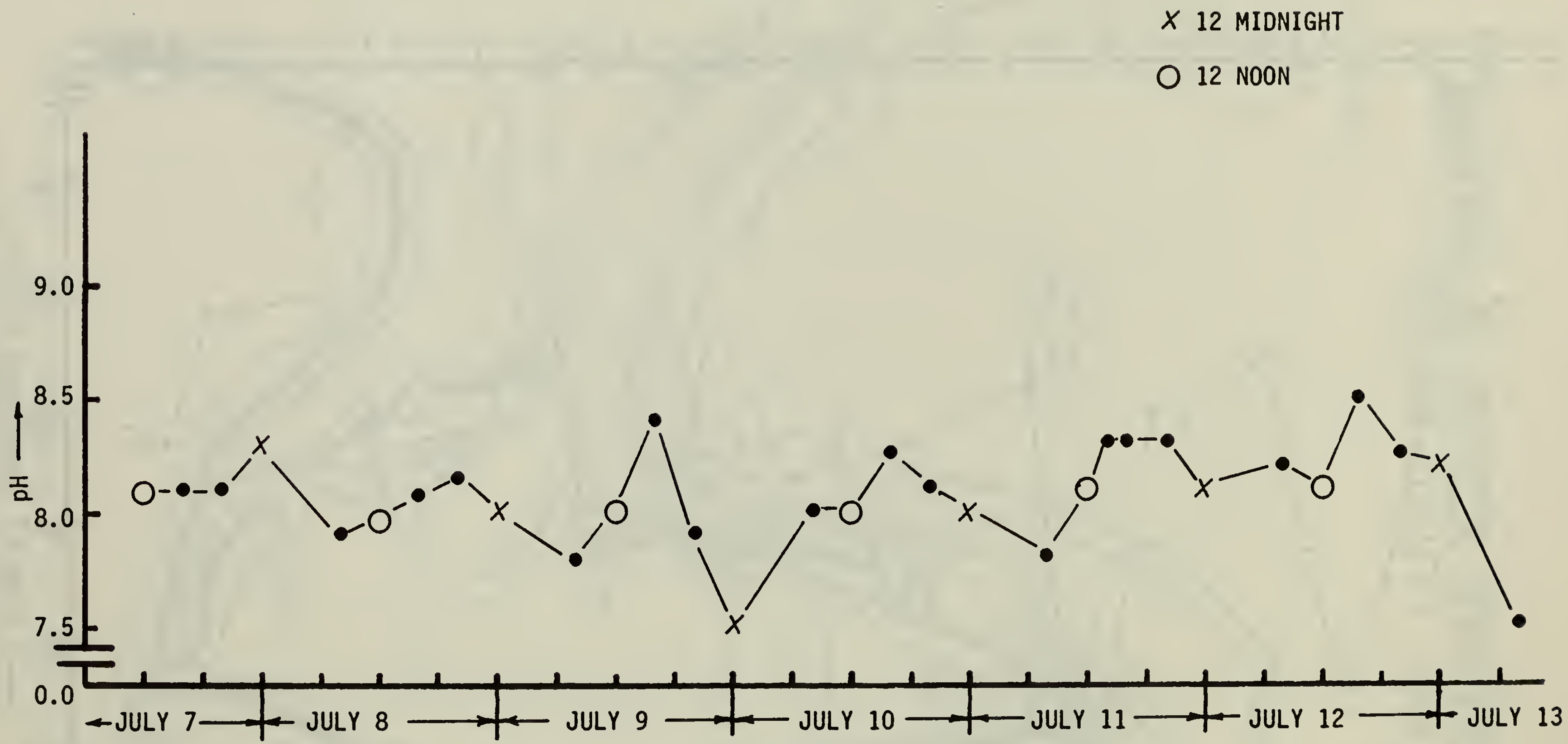

FIGURE B3

pH OF THE BUFFALO RIVER MEASURED AT THE STATION INDICATED IN FIGURE B1.

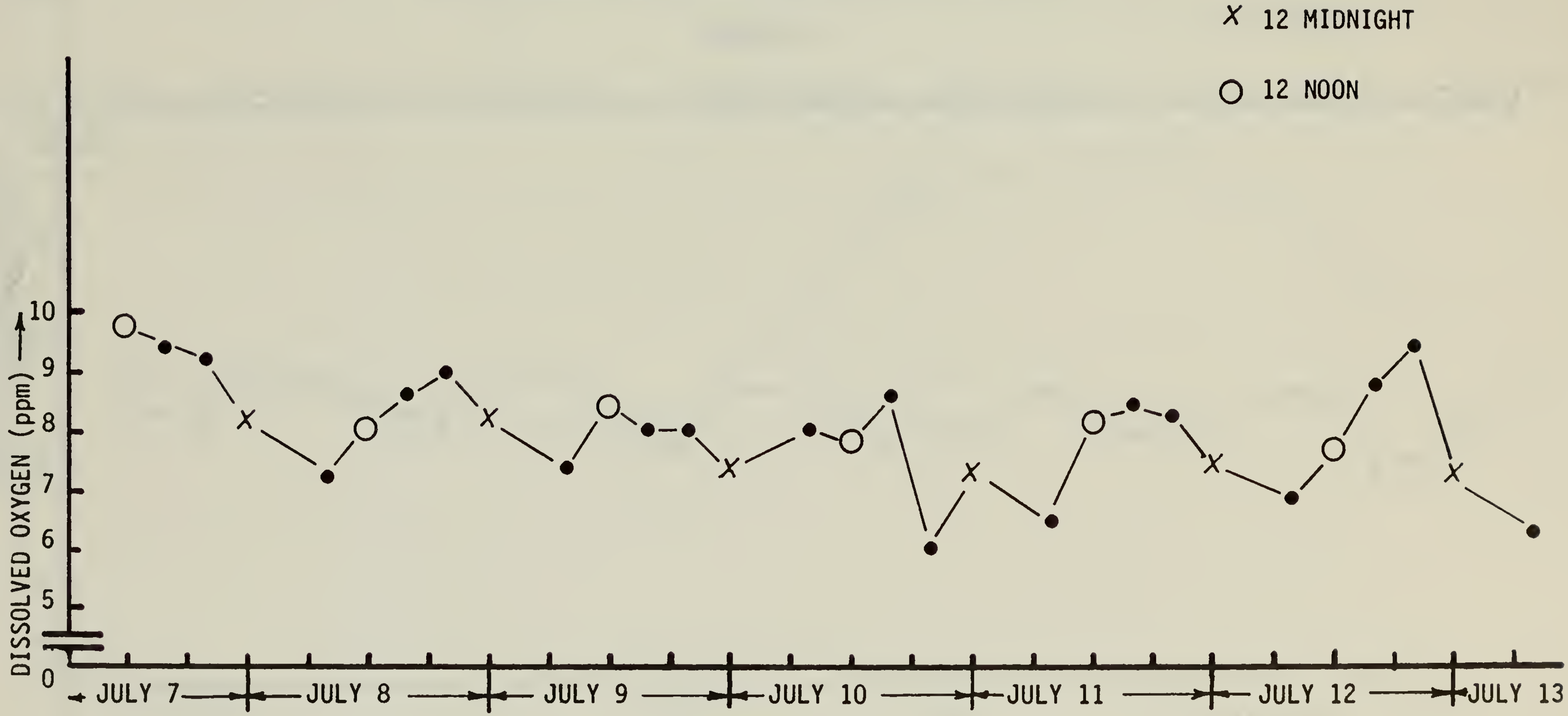

FIGURE B4

DISSOLVED OXYGEN CONCENTRATION OF THE BUFFALO RIVER MEASURED AT THE STATION INDICATED IN FIGURE B1.

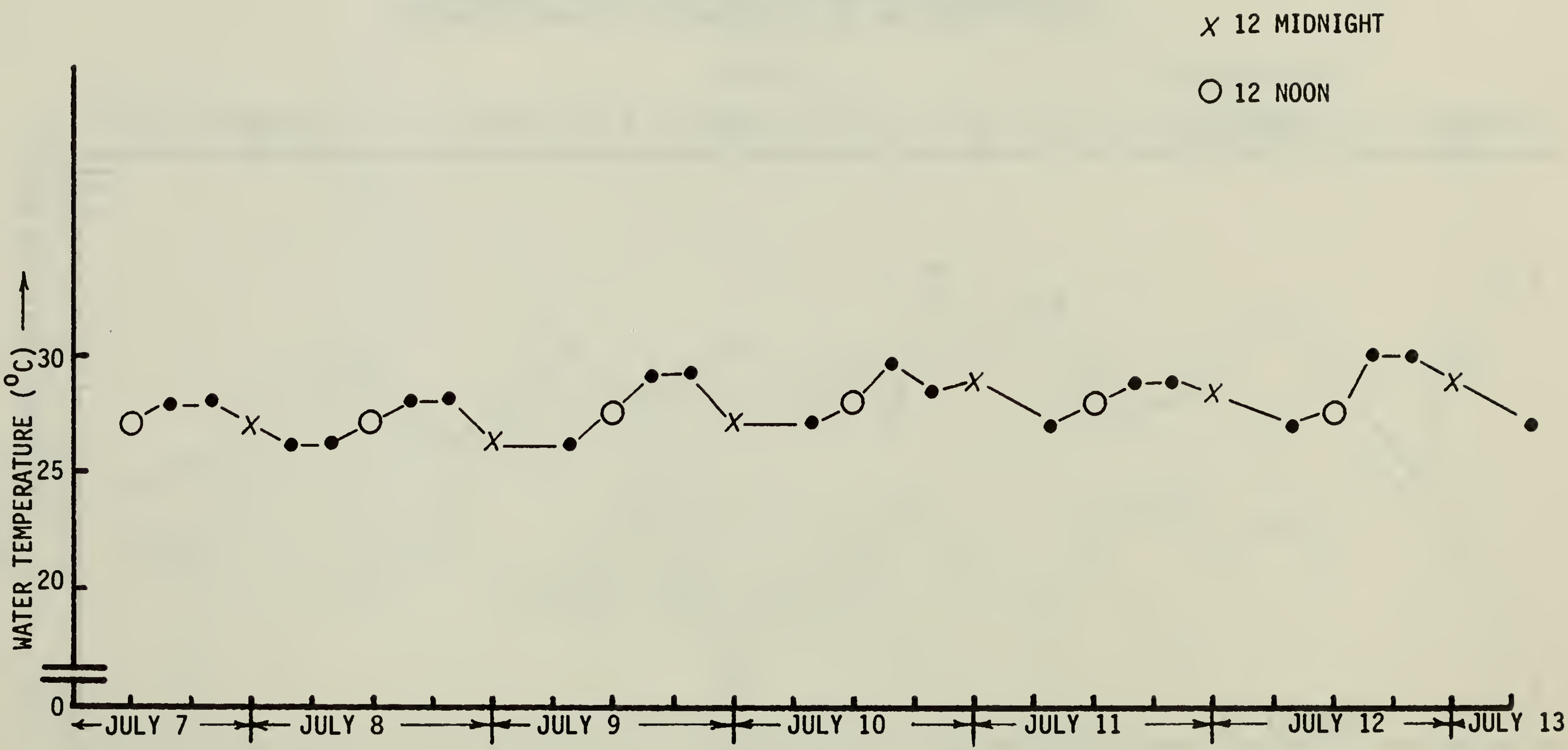

FIGURE B5

WATER TEMPERATURE OF THE BUFFALO RIVER MEASURED AT THE STATION INDICATED IN FIGURE B1.

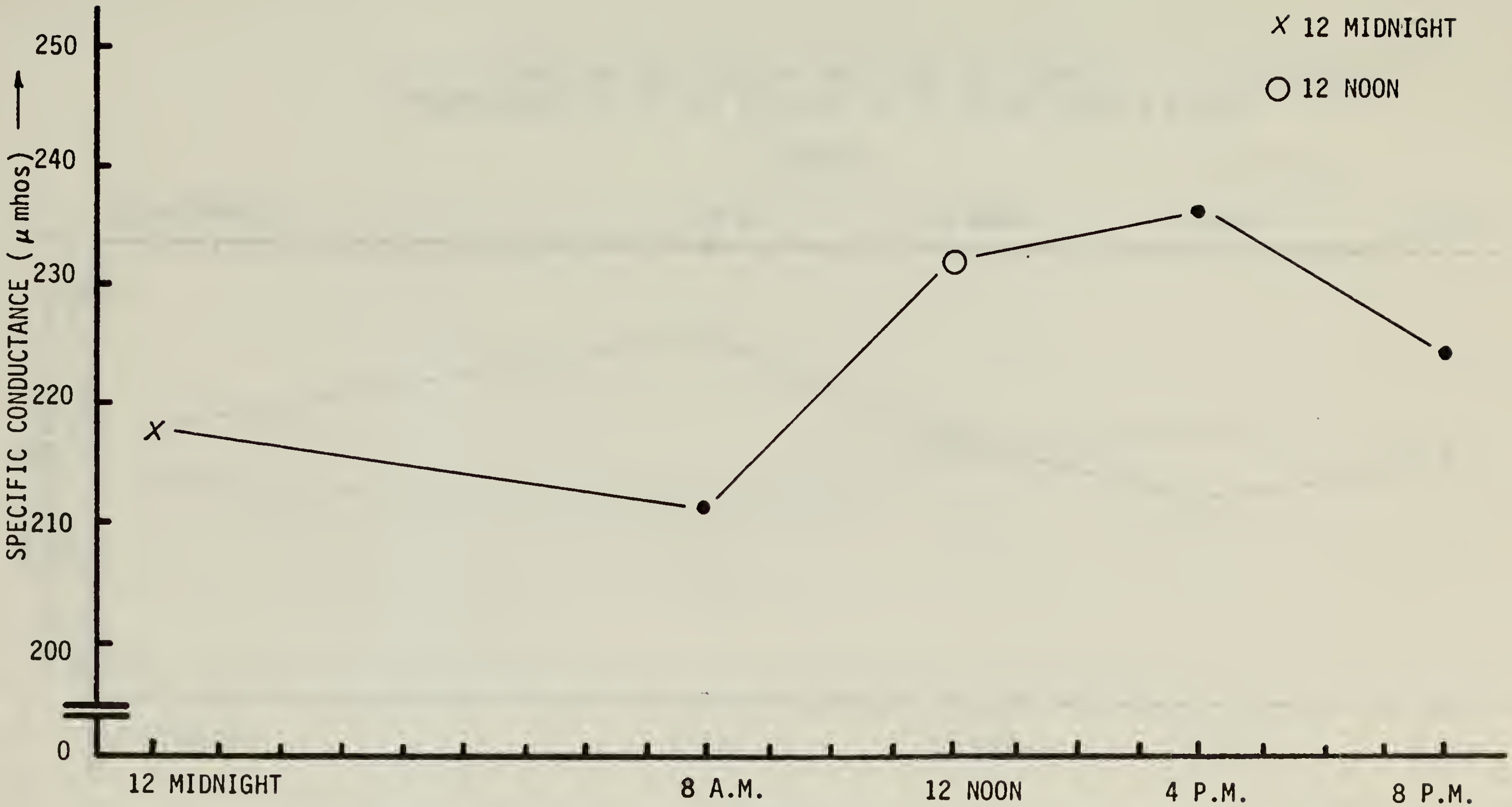

FIGURE B6

AVERAGE FOR TIME OF DAY READINGS OF SPECIFIC CONDUCTANCE OF THE BUFFALO RIVER TAKEN AT THE STATION INDICATED IN FIGURE B1.

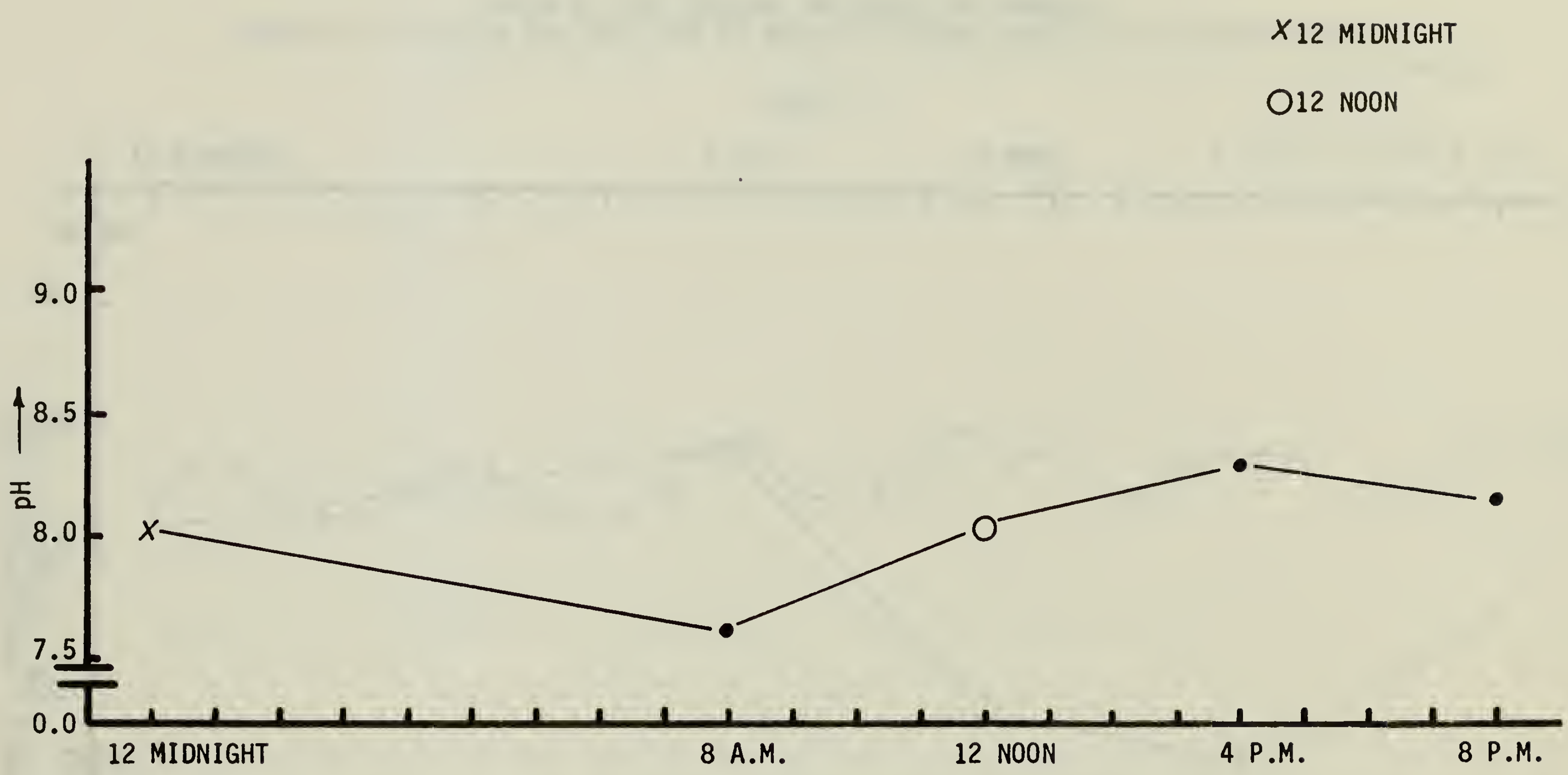

FIGURE B7

AVERAGE FOR TIME OF DAY READINGS OF pH OF THE BUFFALO RIVER TAKEN AT THE STATION INDICATED IN FIGURE B1.

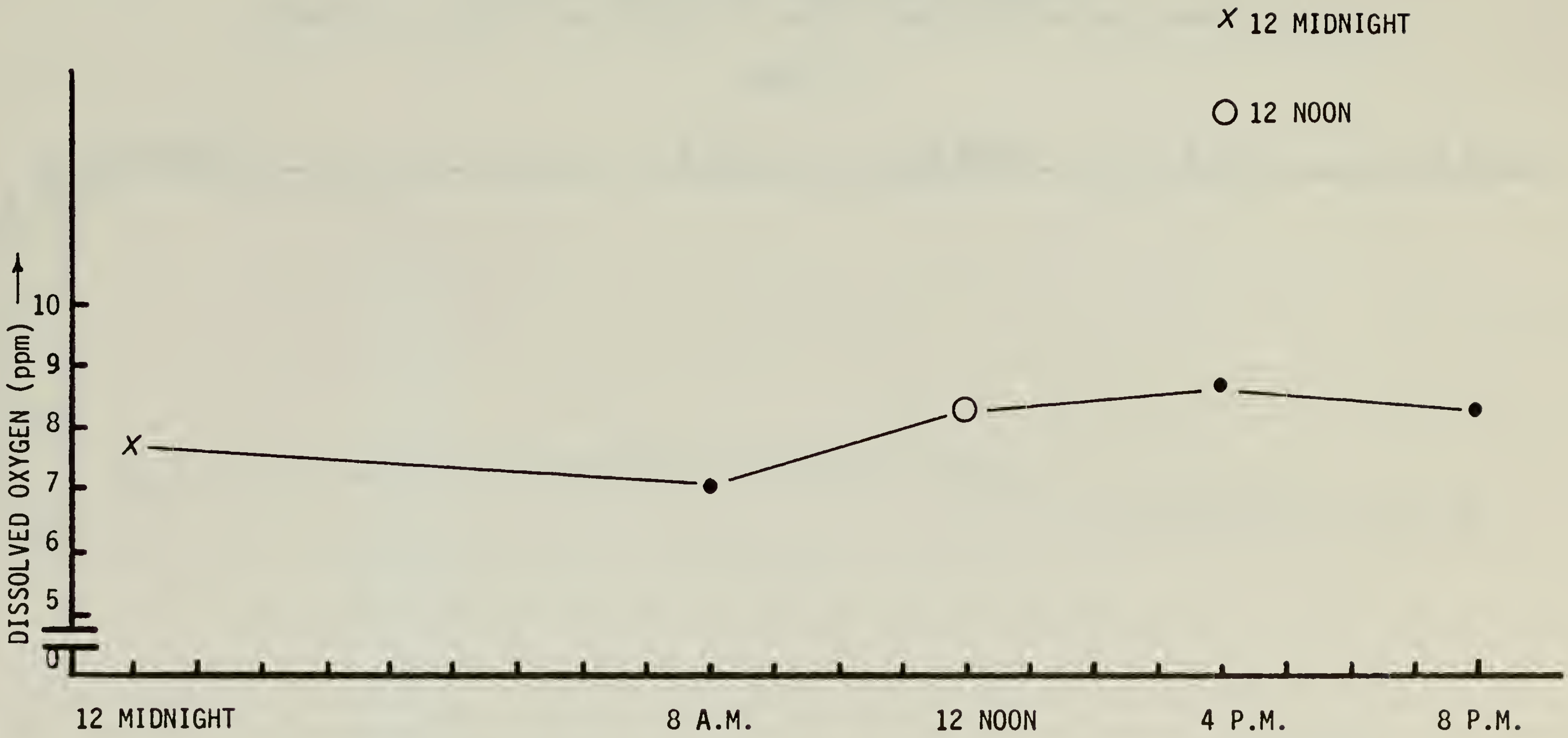

FIGURE B8

AVERAGE FOR TIME OF DAY READINGS OF DISSOLVED OXYGEN CONCENTRATION OF THE BUFFALO RIVER TAKEN AT THE STATION INDICATED IN FIGURE B1.

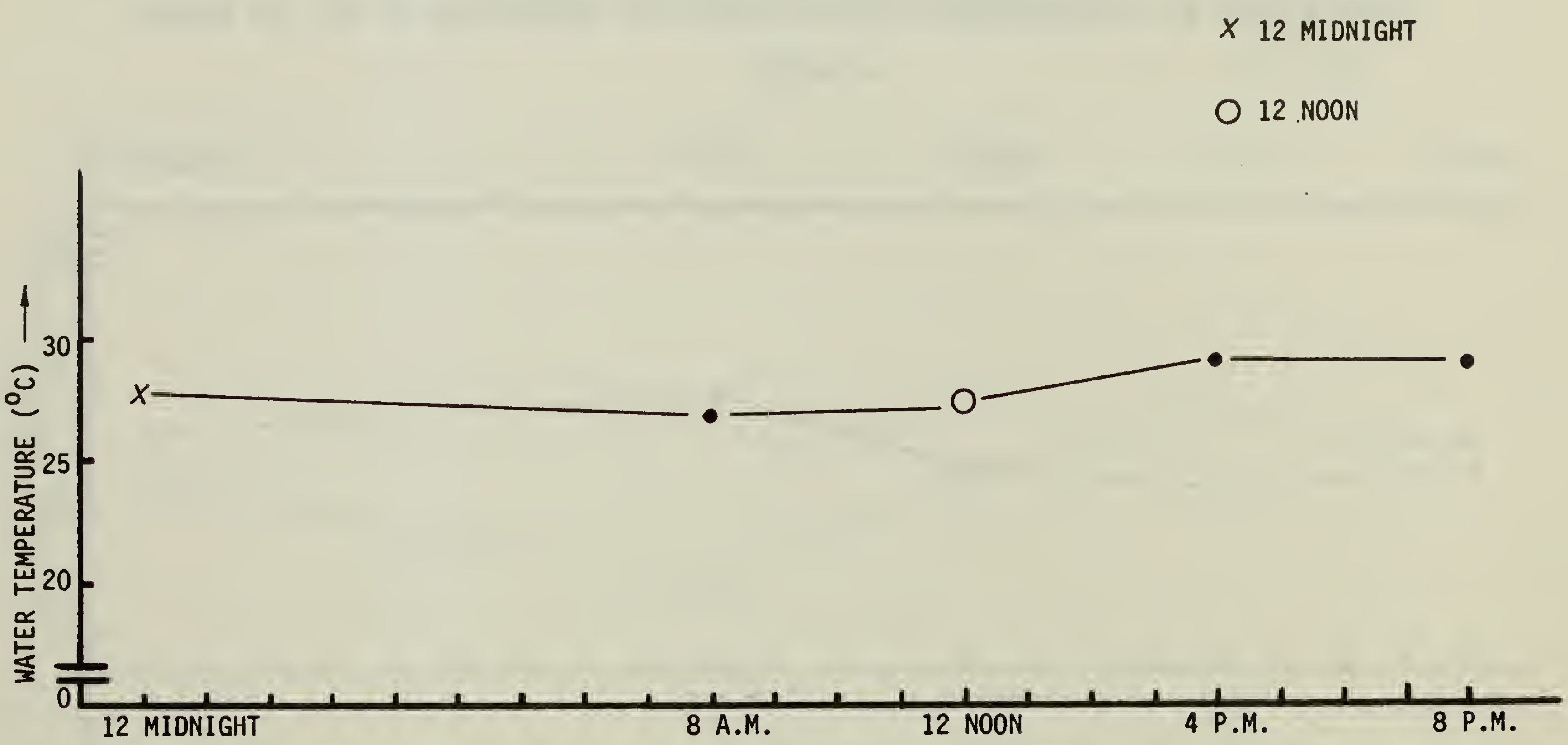

FIGURE B9

AVERAGE FOR TIME OF DAY READINGS OF WATER TEMPERATURE OF THE BUFFALO RIVER TAKEN AT THE STATION INDICATED IN FIGURE B1.